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THE
WORKS
OF THE
HONOURABLE
Robert Boyle, Esq.
EPITOMIZ'D.

VOL. I.

By RICHARD BOULTON, of Brazen-
Nose College in Oxford.

Illustrated with COPPER PLATES.

*Consilium est, universum Opus Institutionis (Philoso-
phicæ) potius promovere in multis, quam perficere in paucis.
Verulamius.*

LONDON,
Printed for J. Phillips at the King's Arms,
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9



IMPRIMATUR

Liber Cui Titulus,

THE
WORKS

Of the HONOURABLE
ROBERT BOYLE, Esq;

EPITOMIZ'D

By RICHARD BOULTON,

JOHN HOSKYNs,

Vicesimo Septimo
Martii, 1699.

V. P. R. S.

E R R A T A.

IN the Preface, pag. 2. lin. 13. read *less* entertaining *Di-*
gressions. P. 34. for *dissolve* into *Crystals*, read *dissolve*, *shoot*
into Crystals. P. 433. l. 7. read *which* would not have been
done, were, &c. P. 436. l. 1. read *in our Third Plate.* In the
Table, under the Letter T. l. 2. dele *their.*

TO THE
Right Honourable
JOHN Lord **SOMMERS**,
BARON of **Evesham**
Lord High Chancellor of **England**,
AND
President of the **ROYAL SOCIETY**;
And to
The Honourable
Sir **JOHN HOSKYNs**,
Vice-President :

Together with the
Council and Fellows
Of the said **SOCIETY**,
INSTITUTED

For the *Advancement of Natural Knowledge* ;

This **VOLUME**, Intitul'd an

E P I T O M Y
OF
Mr. BOYLE's WORKS;

Is humbly Dedicated by

RICHARD BOULTON

TO THE
Right Reverend Father in GOD
NICOLAS,
Lord BISHOP of
CHESTER.

My LORD,

THAT I presume to lay a Book before Your *Lordship*, which bears so mean a Name as mine in the Title-Page, might want a better Apology than I could make, were there not likewise the Illustrious Name of that justly esteem'd and most Famous Author, the Honourable Mr. *Boyle* before it.

For were the following Sheets, entirely the Products of my weak Endeavors only; I should think it no small Piece of Vanity to hope for Your *Lordship's* Notice, and much more to expect your Patronage: But,

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Right Reverend Father in GOD
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Lord BISHOP of
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The DEDICATION.

since the Honourable Author's Works have sufficiently recommended themselves to the Learned World; and more especially to those that are most Eminent for Learning themselves; He cannot but already, amongst Those, have deserved Your good Esteem; and therefore, should I endeavour an *Eucomium* of so Great a Man, by way of Apology for my present Presumption, I should but let Your *Lordship* see, that all I can say of so Eminent a Person, would come far short of the Esteem You have for him already: Not that I can pretend to know Your *Lordship's* Sentiments in any Particular, any further, than I may presume to guess, by the Notion I have of Your *Lordship's* Esteem for Learning and Learned Men.

But tho' the Name of Mr. *Boyle* may be sufficient to recommend the Honourable Author's Works to Your *Lordship*, and the rest of the Learned World; yet if Your *Lordship* will be pleased to condescend to Patronize Your most Humble and Obedient

The DEDICATION.

ent Servant, who hath the good Fortune to Conduct them into the World, and to Extract those purer Streams of Knowledge, which are separated from the less discerning Part of Mankind, by polite Apologies and Florid Complimental Digressions, It will be the greater Happiness, that I have the Honour to be Just to the Author and Serviceable to the World; But much more, that I have at the same time, so Favourable an Opportunity of expressing my Gratitude for the Favours which Your *Lordship* hath already been pleased to bestow on me: Favours, which are much more valuable, because Your *Lordship's*; and which carry with them a double Obligation of Gratitude; the One to Your *Lordship* and the Other to my good Friend and Worthy Patron Dr. *Robert Angell*, to whom I am infinitely Obligated for Your *Lordship's* Favour, and for being first made known to Your *Lordship*.

But it will not be the only Happiness to me, that Your *Lordship* is pleased to Patronize

The DEDICATION.

tronize my present Undertaking; but it may in a great Measure Contribute to their Candid Acceptance by the World, who will put a higher Value upon them, for Your *Lordship's* Favourable Approbation.

Indeed, were it Generally receiv'd and agreed on, what some People hold, *viz.* That *Philosophy* is prejudicial to *Religion*; I should have more Reason to beg Your *Lordship's* Pardon, than Your Patronage; since it must be in Vain to hope, that One, who promotes the Latter, by Instructive Doctrin; and what is more, an Exemplary Life, to be imitated, but not parallell'd; should encourage any thing, that may be of Disservice to that: But I need not tell Your *Lordship*, that the Honourable Author hath made it appear, That we may search into *Efficient Causes*, without denying the All-Wise *Author* of Created Beings, his just Attributes: For, whoever diligently searches into *Efficient Causes*, cannot but discern the Necessity of an Omnipotent

The DEDICATION.

otent Creator, who first establish'd the
aws of Nature, and gave them their due
imits; and our Author having made it
vident, that *Efficients* themselves, direct us
o *Final Causes*; and consequently rather
spose and incline a Man, than hinder him
om being a Good *Christian*; your *Lord-*
ship needs no other Inducements to pro-
ote it.

And indeed, were I not satisfy'd, that
Philosophy, if rightly made use of, by the
ffects it hath upon my Self, did not en-
ble Me the more to discern the Shortness
of the Utmost Attainments of Finite Ca-
acities, and to adore what I cannot com-
rehend; I should be so far from desiring
Your *Lordship's* Patronage, that I should
e ready to oppose it my self, to the utmost
of my Weak Endeavours: And were it not
oo soon to make Your *Lordship* Promises,
efore I have qualify'd my Self to write
ny thing of my own, worth Your *Lord-*
ship's Notice, I should not be backwards
o say, That I may in a few Years, shew
that

The DEDICATION.

that it will afford us no small Light in explaining the *Mosaick* Creation, in directing us to frame some faint Ideas of the Methods by which the Omnipotent *Fiat* brought the World to what it now is, and to prove the Works of the Omnipotent Creator, as Historically deliver'd by *Moses*, consonant with *Philosophy*.

But I am afraid, that, endeavouring to make an Apology for this Dedication, I ought to make another, for having been too tedious already; since Your *Lordship's* own Judgment, will satisfy You of the Usefulness of *Philosophy*; and since that Consideration is enough to induce You to encourage it.

Yet I cannot persuade My self, so soon to pass by this Opportunity of expressing my Gratitude to Your *Lordship*; nor can I forbear reflecting on my own Happiness, under Your *Lordship's* Patronage: For as no one better understands, how to encourage the Endeavours of those, that make Im-
prove-

The DEDICATION.

Improvements in Knowledge their Aim, than those that are most intimately acquainted with it, and than Your *Lordship*; So it is an equal Happiness to be under the Protection and Favourable Eye, of a Patron so desirable: Neither is it any Vain Opinion I have of my own Merit, that makes me think my self Happy under such a Patron, but rather the Sense of my own Weakness; For could I persuade my self that I deserv'd Your *Lordship's* Favour, or the Favour of some Others, both Eminent and Learned, to whom I am oblig'd: I must be very vain indeed.

But notwithstanding the Sense I have of my own Weakness, Your *Lordship's* Favour will encourage me to improve the small Talent I have, since in the Search of Truth,

Est aliquid prodire senus, si non datur

ultra.

But

The DEDICATION.

But My LORD, the World, who are wont to find in *Dedications*, the Characters of their *Patrons*, may wonder that I have declin'd the Usual Method, since any one that knows Your *Lordship* cannot want Materials for a Character, that might be of Use to the World, in setting them a Good Pattern to imitate : Yet since Your *Lordship's* Character would be drawn amiss by so mean a Pen as Mine; I would rather be thought out of the Common Road, than mistaken in it; since any Body that knows what Character belongs to a Truly *Apostolical Bishop*, is not unacquainted with Your *Lordship's* : Therefore since no *Encomiums* can add to that which can only be augmented by a Continuance of Your Life; the Fear of Mis-representing, is the Reason I decline it.

But not to take up too many of Your *Lordship's* pretious Minutes, which are always Employ'd in doing Good, and promoting *Christianity* in it's Original Stream; that Your
Lord

The DEDICATION.

Lordship may live long, for the Honour of
the Church, and the Good of those that are
under Your Care, is not only the Wishes of
those that think themselves happy under the
inspection of Your *Lordship*; but more par-
ticularly of,

My LORD,

Your LORDSHIP's

Most Dutiful, and

Most Obedient

Servant,

RICHARD BOULTON.

THE DEDICATION.

Friendship may live long, for the Honour of
the Church, and the Good of those that are
under Your Care, is not only the Witness of
those that think themselves happy under the
Inspection of Your Friendship; but more par-
ticularly of

MY LORD,

Y^r LORDSHIP,

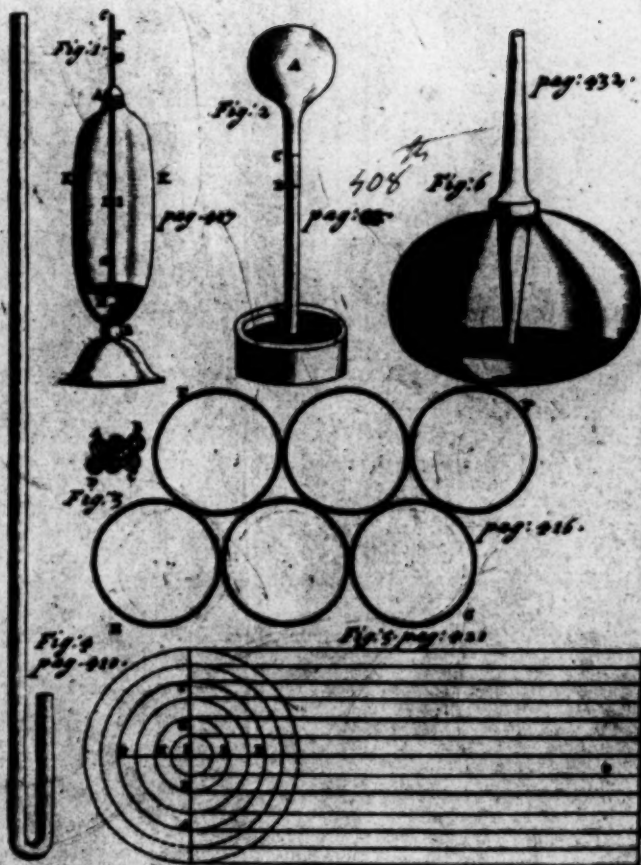
Wth Respect, and

Most Obedience

Yours,

RICHARD BOULTON.

Plate the Second



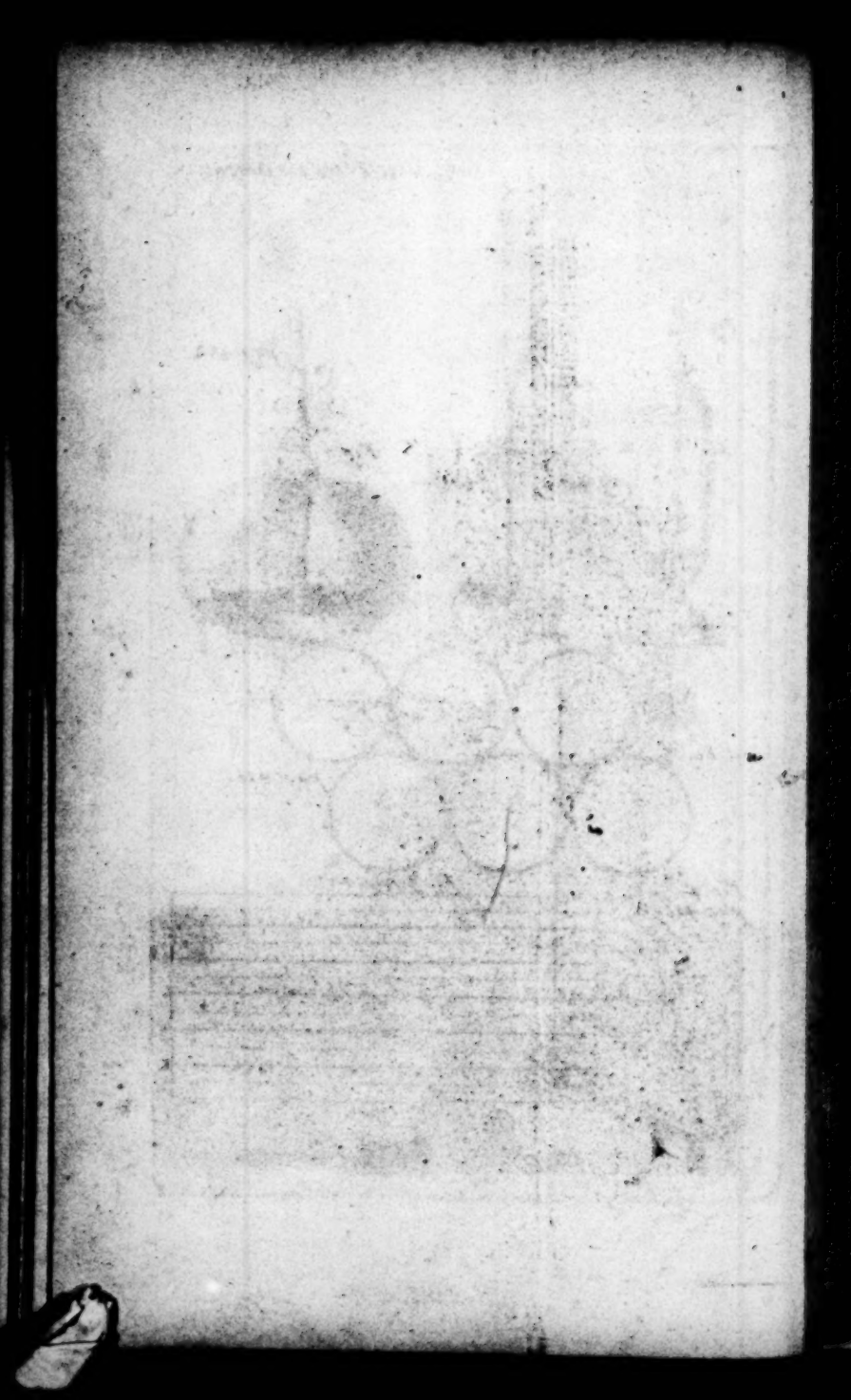
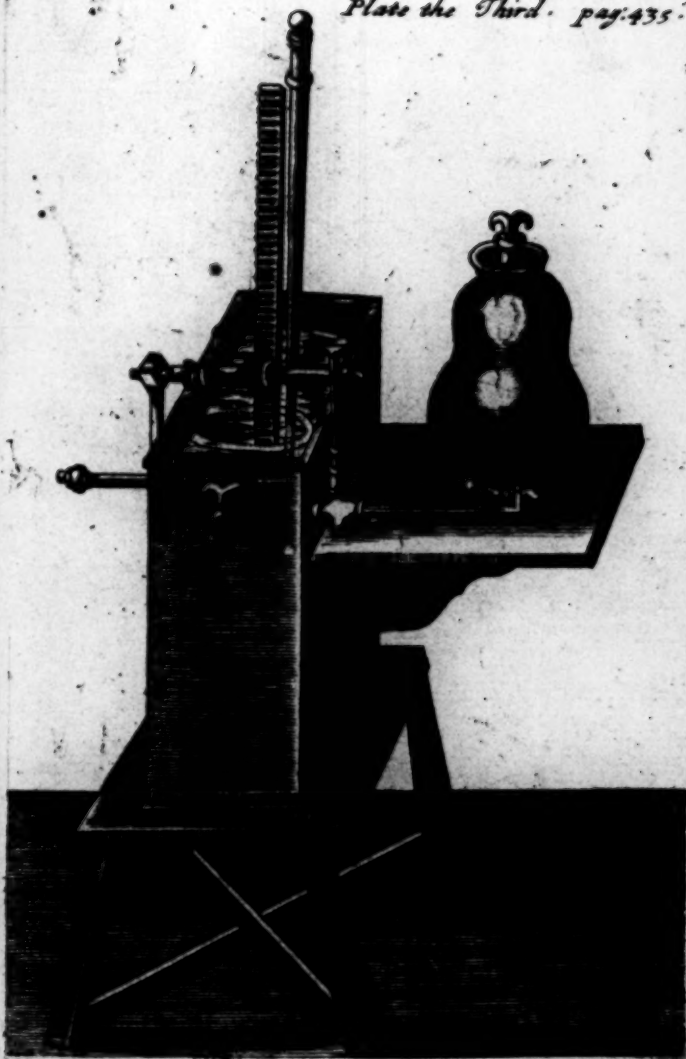


Plate the Third. pag. 435.



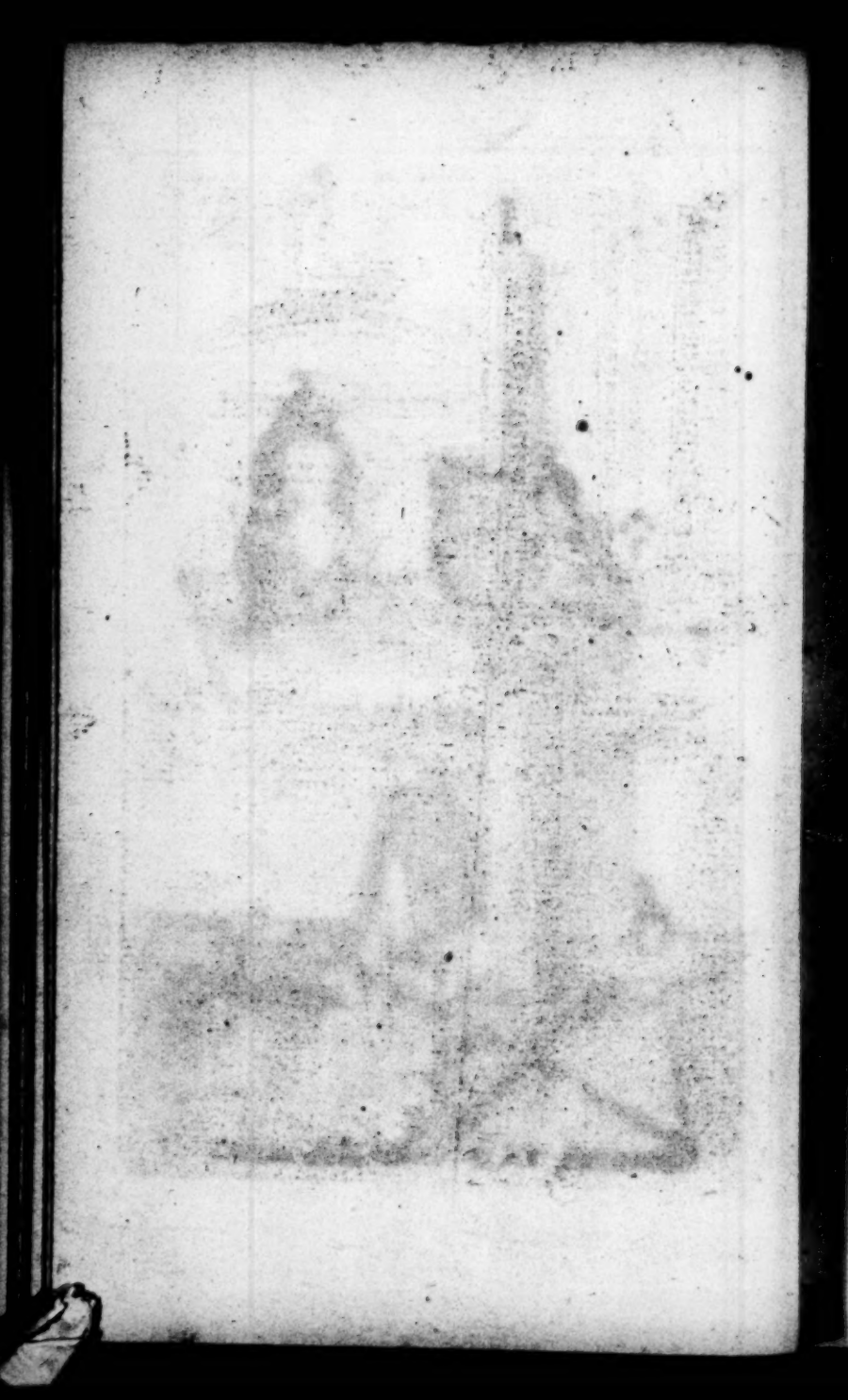


Plate the
fourth.
Pag: 935.

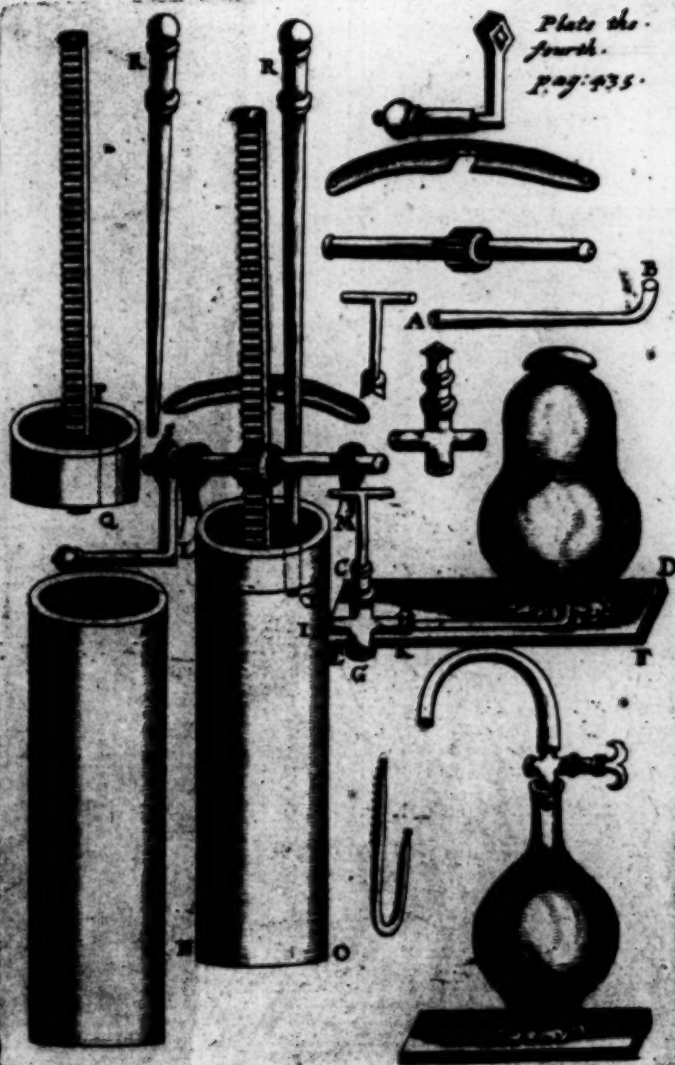




Fig. 1. pag. 438.



Fig. 3. pag. 454.



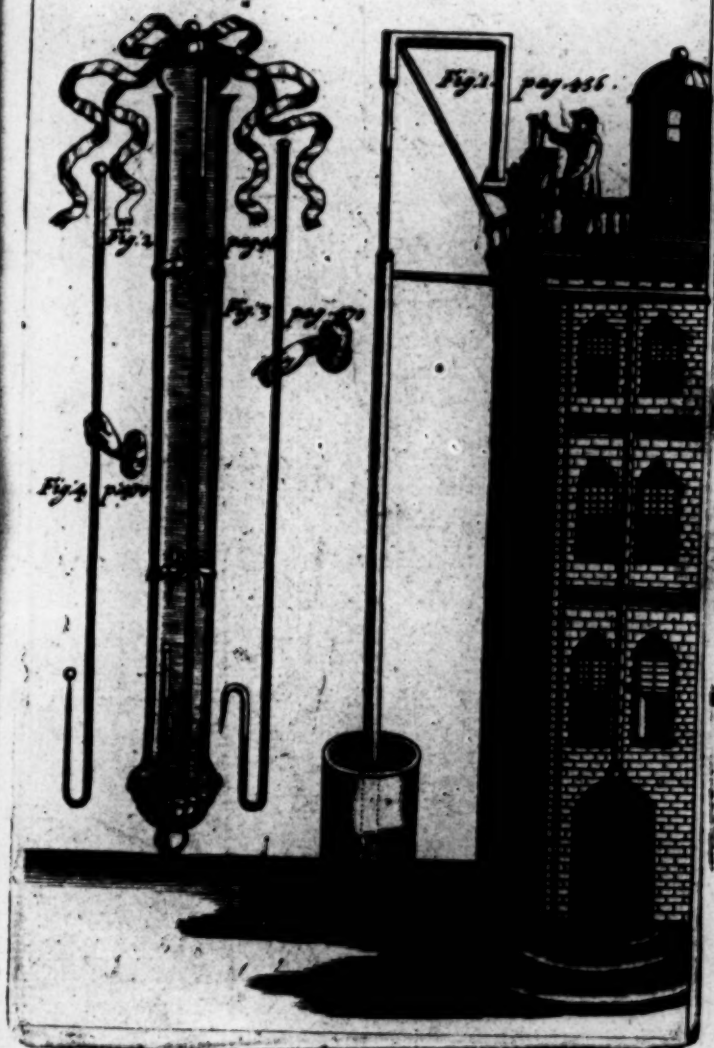
Fig. 2. pag. 452.

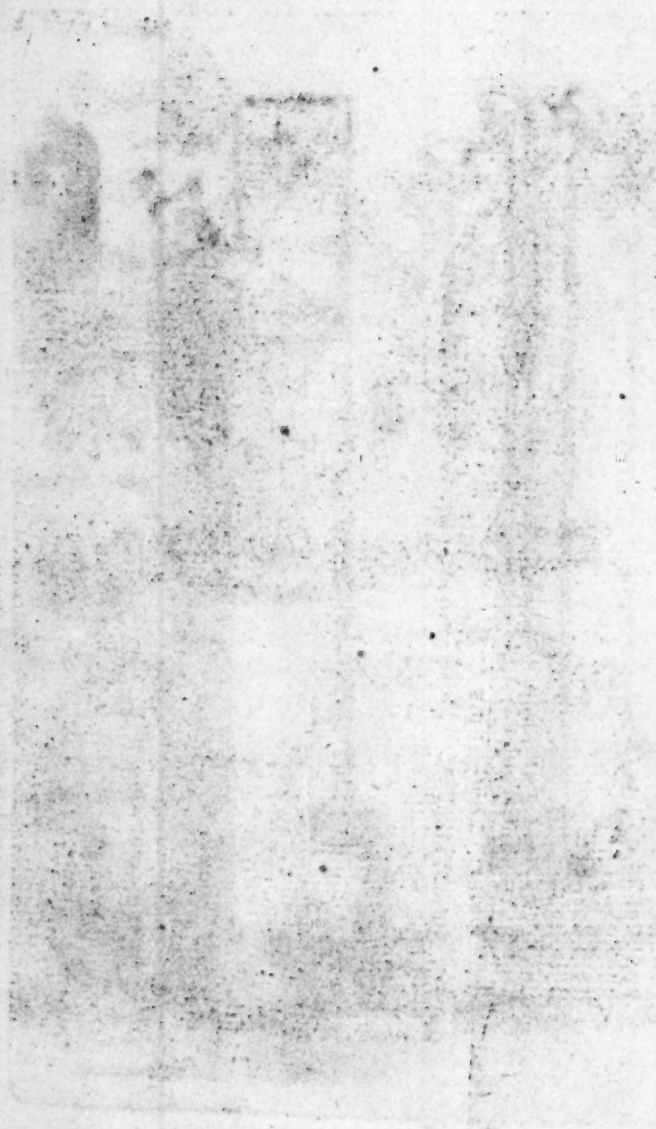


Fig. 4. pag. 454.











THE
WORKS

Of the HONOURABLE
ROBERT BOYLE, Esq;
EPITOMIZED.

BOOK I.

CHAP. I.

*Considerations and Experiments concerning the
Origin of Forms and Qualities.*

THAT before I descend to a more particular Consideration of the Doctrin of *Forms and Qualities*, I may premise some General Apprehensions of the Doctrin, to be collated with, and to be either confirm'd, or disprov'd by what follows of Particular *Forms and Qualities*; I will, at the Entrance, give you a short Account of our *Hypothesis*, compriz'd in the Eight following *Particulars*. We teach then (but without peremptorily asserting it)

*The Divi-
sion of this
Chapter,*

A

I. That

Matter De-
fin'd.

I. That the Matter of all Natural Bodies is the same, Namely, a Substance Extended, Divisible and Impenetrable.

Motion the
Catholick
Agent of
the Uni-
verse.

II. That since there could be no change in Matter, if all its Parts were perpetually at rest amongst themselves, to discriminate the *Catholick Matter* of the Universe, into a Variety of *Natural Bodies*, it must have Motion in some or all its Parts, which Motion must be variously determined.

And though it is manifest to Sense, That there is *Local Motion* in Matter, yet Motion is not congenite to Matter, nor coeval with it, *Local Motion* being not included in the Nature of Matter, which is as much Matter when at rest as in Motion: And though it be hotly disputed, How Matter came by that Motion, by those who acknowledge not an Author of the Universe; yet, since a Man is not the worse *Naturalist*, for not being an *Atheist*, we allow that the Origin of Motion in Matter is from GOD; and that, since it is unfit to be believ'd, that Matter in Motion left to it self, should ca-

Guided by
GOD in
the Crea-
tion of
Things.

sually constitute this Beautiful and Orderly World, it is not amiss to think, That the Wise Author of Things, guided the first Motions of the small Parts of Matters so, that they might convene after a Manner requisite to compose the World, and especially did contrive those Curious and Elaborate Engins, the Bodies of Living Animals, enduing most of them with a Power of propagating their *Species*. But to pass by such Notions, I shall proceed to what remains requisite to explicate the Origin of *Forms* and

and *Qualities*, as soon as I have taken Notice, That *Local Motion* seems to be indeed the Principal amongst Second Causes, and the Grand Agent of all that happens in Nature; Bulk, Figure, Rest, Situation and Texture, being the Effects of Motion, or the Conditions and Requisites, which Modify the Operation, as in a *Watch*, or *Key*, it is Motion that makes all the other Requisites useful.

III. That Matter being Naturally by a variously determined Motion, divided into Parts, each of those Parts must needs have a peculiar *Size and Shape*: So that there are three Essential Properties, or Primary Affections of the Parts of Matter, *Magnitude, Shape*, and either *Rest* or *Motion*; the two first of which may be call'd *Inseparable Accidents*: Inseparable, because Bodies extended and finite, cannot be devoid of a Determinate Shape; Accidents: because that whether *Physical* Agents may have a Power to alter the Shapes, or subdivide Bodies or not, yet mentally they may do both without destroying the Essence of that Matter.

Whether these Accidents may be call'd the Modes, or Primary Affections of Bodies, to distinguish them from those more compound Qualities (as Colours, Tastes, and Odours) or the Conjuncts of the smallest Parts of Matter, I shall not now determine; only one thing which is taught by the Modern Schools concerning Accidents; Namely, That there are in Natural Bodies *Real Qualities*, and other *Real Accidents*, which are no Modes of Matter, but Entities distinct from it, and which may exist separate from all Matter. To clear this Point, we must take

Notice, That *Accident* is used in two several Senses; for sometimes it is opposed to the fourth Predicable (Property) and is defined, *That which may be Present or Absent, without the Destruction of the Subject*; as a Man may be sick or well, yet a Man: And this is call'd *Accidens Pradicabile*, to distinguish it from what they call *Accidens Pradicamentale*, which is opposed to Substance; and as Substance is commonly defined to be a thing that *subsists of it self, and is the Subject of Accidents*; so Accident is said to be *Id cuius esse est inesse*: And therefore *Aristotle*, who usually calls Substances *ὄντα*, Entities, calls Accidents *ὄντα ὅντων*, Entities of Entities, these needing a Subject of Inhesion. And we are likewise to take Notice, That, according to them, *That* is said to be in a Subject, which hath these three Conditions; That however it (1) be in another thing, (2) is not in it as a part, and (3) cannot exist separately. This premised, it will appear easily, that if they will not allow these *Accidents* to be *Modes of Matter*, but *Entities* really distinct from it; they make them indeed *Accidents* in Name, but represent them under such a Notion, as belongs only to *Substances*, the Nature of a *Substance* consisting in this, that it can subsist of it self. So that we may consider, when a *Bowl* runs along or lies still, that *Motion* or *Rest*, or *Globous Figure*, are not any parts of the Bowl, nor real and Physical Entities distinct from it, but certain Modifications, and several Capacities in relation to the Matter of that Bowl.

*An Excursion about the Relative Nature of
Physical Qualities.*

BUT because this Notion about the Nature of *Qualities* may be of some importance, I shall illustrate it a little further. We may consider then, That whoever was the first Inventor of *Locks* and *Keys*, they both consisted of a piece of Iron, of a determinate Figure; but in respect of the Congruity betwixt the Wards of the *Locks*, and those of the *Keys*, they each of them obtained new Capacities; it being a peculiar Faculty of the *Key* to unlock, as of the *Lock* to be unlocked by it; yet by these new Attributes, no real or Physical Entities were added, either to the *Lock* or *Key*: so those Qualities, which we call Sensible, tho' by virtue of a Congruity or Incongruity in point of Figure or Texture to our Sensories, the portions of Matter they modifie, are enabled to produce various Effects, upon whose account we make Bodies to be endued with Qualities, yet they are not in those Bodies any real distinct Entities, or different from the Matter it self, furnished with such a determinate Bigness, Shape, or other Mechanical Modifications. It is reckoned amongst the principal Properties of *Gold*, that it is dissoluble in *Aqua Regis*; and if one should invent another *Menstruum*, that will in part dissolve pure *Gold*, yet the Nature of *Gold* is not at all different now, from what it was before either of those *Menstruums* were invented, there no new real Entities accruing to it, without the Intervention

*Qualities
the result
of a pecu-
liar Modifi-
cation.*

of a Physical Change in the Body it self, by the Addition of these Attributes.

Proved
by Physical
Observa-
tions.

There are some Bodies neither *Cathartick*, nor *Sudorifick*, with some of which *Gold*, being embodied, acquires a Purging Virtue, and with others *Diaphoretick* Qualities; and Nature her self doth, either Artificially, or by Chance, produce so many things, that have new Relations unto others: And, *Art* especially assisted by *Chymistry*, may, by variously dissipating Natural Bodies, or compounding either them or their constituent Parts with one another, form a multitude of new Productions, which will be able each of them to cause new Effects, either immediately upon our Sensories, or upon other Bodies, whose changes we are not able to perceive; so that no Man can know, but that the most Familiar Bodies, may have a multitude of Qualities, that he dreams not of; and a considering Man will hardly imagine, That so numerous a crowd of real Physical Entities can accrew to a Body, whilst in the Judgment of all our Senses it remains unchanged.

Again, *Glass* beaten is commonly reckoned amongst Poysons; which deleterious Faculty is no superadded Entity distinct from the *Glass*, but depends on the sharp Points and cutting Edges of the Fragments, which by *Mechanical* Affections, cut and wound the Membranes of the Stomach and Guts; from whence follow great Gripings and Contorsions, and often a Bloody Flux by the Perforations of the Capillary Vessels, and horrid Convulsions by the consent of the Brain and *Cerebellum*, as also great Dropsies, occasioned by the loss of Blood: And that those Effects depend on the Edges and Points of the

the Fragments, appears, because when the Guts are sufficiently lined with Slime, or the Corpuscles of the *Glass* are ground fine, they pass without damage along with the Excrements.

And this may put us in mind, That the Multiplicity of Qualities, in the same Natural Bodies, may proceed from the bare Texture, and other *Mechanical* Affections of its Matter: For every Body is to be considered not barely as an entire distinct Portion of Matter; but as it is a Part of the Universe, placed amongst a great number and variety of other Bodies, upon which it may Act, and by which it may be Acted on, in many ways, which are falsely thought to be distinct Powers or Qualities in the Bodies, by which those Actions and Passions are produced. And every Portion of Matter thus considered a few *Mechanical* Affections are sufficient to diversify it from other Bodies: As in a *Watch*, there are a great many Qualities; as to shew the Hours, to strike, to give an Alarm, or to shew the Age of the *Moon* and Tides; yet these are all to be attributed to the determinate Shape and Texture of the Parts of it, and the Motion of the Spring. So the *Sun* hath a Power to harden Clay, and soften Wax, to melt Butter, and thaw Ice, and a great many more, which seem contrary Effects; yet these are not distinct Faculties in the *Sun*, but the Productions of *Heat* diversify'd, by the different Textures of Bodies it chances to work upon.

And thus much (*Pyrophilus*) may serve to remove the Mistake, That every thing Men are wont to call a Quality, must needs be a Real and *Physical* Entity. To conclude this *Excursion*, I

shall add this short Advertisment, That to make what I have declared more intelligible, I have rather done it by Examples, than Definitions; the latter being more difficult, because of the difficulty of assigning the true *Genus's* of Qualities. And,

Here it may not be amiss to take Notice, That *Aristotle* himself does not only define *Accidents*, without setting down their *Genus*; but when he comes to define *Qualities*, tells us, That *Quality* is that by which a Thing is said to be *Qualis*; which is to define the *Thing* by the *Same*, without denoting its *Genus*; for 'tis supposed to be as little known what *Qualis* is, as what *Qualitas*. Besides, 'tis a Doubt whether it be not as false as obscure; for to the Question *Qualis res est*, Answer may be made out of some, if not all of the other *Pradicaments of Accidents*.

Posture,
Order and
Texture Secondary
Affections of
Matter.

IV. Besides the foremention'd *Primary Affections of Matter*, viz. Motion, (or Rest) Bulk and Shape; which a portion of *Matter* singly by it self must have; if all the rest of the Universe were annihilated, there being now in the Universe multitudes of *Corpuscles* mixed together, there arise two new *Accidents*, or *Events*: The one relates to its *Posture*, in reference to the Bodies about it (whether erected, inclined or horizontal) and the manner of those Bodies in reference to each other, which may be called *Order*; as *Aristotle* in his *Metaphysics* recites this Example, from the Ancient *Corpuscularians*. A and N differ in *Figure*, and A N, and N A in *Order*; Z and N in *Situation*; and *Posture* and *Order* indeed seem both reducible to *Situation*. And, lastly, when these *Corpuscles* do so convene, as to make

make up a Body; the Disposition and Contrivance of Parts in the whole, may be called the *Texture* of it.

V. We are to consider, That the Bodies of Sensible and Rational Beings, being endued with several Senses, adapted so, as to receive from without various Impressions, according to the Diversity and peculiar *Texture* of each Part; these Impressions being falsely imagined to proceed from real Qualities, inherent in those several Objects, have been signify'd by several Names, as Heat, Colour, Sound, Odour, together with a vast variety of each, as so many *Species*, to be rank'd under these *Genera*; which really depend on the Figure, Shape, Motion, Texture, and the Manner in which these Bodies, differently modify'd, variously affect the Senses.

VI. But here is one Difficulty to be remov'd, which is, That besides the Sensible Qualities, evident in Relation to our Senses, they have an absolute Being irrelative to us; since they do not only Operate upon our Senses, but other inanimate Bodies. To clear which, I have several things to represent.

1. That there are Simple, and more Primitive Affections of Matter, from whence these Secondary Qualities do proceed, and on which they depend. *But Secondary Effects of Matter.*

2. The Knowledge we have of the Operations of Bodies, proceeds from some Sensible Quality, or some more *Catholick* Affection of Matter; as Motion, Rest, or Texture; generated, or destroy'd in one of them.

3. We are to consider every distinct Body that affects our Senses, not as a bare Lump of Matter, of

of that Bigness and outward Shape that it appears of, most of them having their Parts curiously contriv'd, and in Motion too. And likewise we are to consider the Universe that surrounds us, as a great *Engine*, with no Vacuity, or no considerable one betwixt its Parts; and the Actions of Particular Bodies, are not to be estimated, as if two Portions of Matter of their Bulk and Figure, were plac'd in some Imaginary Space beyond the World, but as situated in the World, as now constituted, and their Actions liable to be promoted, or hinder'd, or modify'd by the Actions of other Bodies about them; for it is not giving of a Concave *Speculum*, that Figure, that enables it to burn Wood, or melt Metals; but the Sun-Beams thrown together into a Point, by the help of that Concavity. And to shew how various and different Effects the same Action of a *Natural Agent* may produce, according to the several Dispositions of the Bodies it works upon, we may consider, That tho' in two *Eggs*, the one Prolifick, the other Barren, before *Incubation*, the Sense can distinguish no Difference; yet their internal Disposition is so different, that if they be both expos'd to an equal Degree of Heat, the one will be chang'd into a putrid *Fetid* Substance, and the other into a *Chick*, furnish'd with a variety of Organical Parts of very curious *Textures*.

4. I grant that Bodies may have those Qualities we call *Sensible*, tho' there were no Animals in the World, every Body having such a Disposition of its Constituent *Corpuscles*, which duly apply'd to the Sensory of an Animal, would produce a Sensible Quality, which another would
not.

not. So that if there were no Sensitive Beings, those Bodies that are now the Objects of our Senses, would be but *Disposively* endued with Colours, and the like, and *Actually* only with those more *Catholick* Affections of Bodies, Figure, Motion, Texture, &c. To illustrate which, we may consider, That, tho' an *Eccho* is suppos'd to be a Peculiar Faculty, in the *Rock*, yet it is nothing but a Repercussion, and the undulated Motion of the *Air*, reverberated by that *Rock*, which striking upon the Ear, causes such a Sensible Quality.

5. The Sensible Qualities, which are acquir'd by the Action of one Body on another, are no otherwise produc'd, but by some Local Motion of Parts, or some change of Texture produc'd by that Motion: For, when a Pin, by a Dissolution of the Continuity, causes Pain, that Pain is only a Consequent of its Motion, which superadds no real Quality to the Pin, which it had not before: And therefore I shall intimate, That when for shortness of Speech, I make use of the Word *Qualities*, I would be understood to mean them in a Sense suitable to the Doctrin above-mention'd. As when I would say, Roughness is apt to offend and grate the Skin, I would mean, That a File or other Body, by having upon its Surface a multitude of hard, and extant Parts of an Angular or Sharp Figure, is qualify'd to cause the mention'd Effect.

Qualities
act by vir-
tue of Lo-
cal Mo-
tion.

Of the Nature of a Form.

VII. We may now consider further, that certain conspicuous Accidents being associated into Bodies; those Bodies are distinguish'd by *Genus's* and

Form the
result of a
Congeries
of united
Accidents.

and *Species*, as they are referr'd to a more Comprehensive sort of Bodies, or to a narrower *Species*, or *Individuals*: As amongst *Fossils*, the *Superior Genus* comprehends both Metals, Stones, &c. each of which *Concretes*, in respect of that *Genus*, are *Species*, comprehended, as they are *Fossils*, under that *Superior Genus*.

Now when those Accidents, which are Essentially requisite to compose a Body, of this or that Kind, are united; the Texture of that Body is call'd the *Form*: which, tho' some think to be a kind of Soul, which, when united to a Natural Body, acts in it, by virtue of several Qualities inherent in that Soul, yet, really, it is nothing distinct from that Matter, but only such an Agreeable Convention of Accidents, as by common Consent, are reputed sufficient to make a Portion of Universal Matter belong to this or that Determine *Genus*, or *Species* of Natural Bodies. And those Qualities in Bodies, which are usually ascribed to the Substantial *Form*, do not proceed from any Real Substance distinct from Matter, but a Convention of those Primary Mechanical Affections of Matter before-mention'd; viz. Bulk, Shape, Motion or Rest; and the Texture thence Resulting, which is the *Form*, or *Essential Modification*; which Convention of Accidents are capable of performing what we usually ascribe to a *Form*, since they are sufficient to discriminate it from all other *Species* of Bodies.

The Effects
of Forms
and Agency.

And since the Form of a Body by some is asserted to be the Principle of its Operations, it may not be amiss here to take Notice, That besides those Operations, that proceed from the *Essential Modification* of the Matter, the Body being

being considered *per modum unius*, as one entire Agent, it may have several other Operations in Respect of the Particular *Corpuscles* of which it is compos'd; as in a *Watch*, besides those things it does as a *Watch*; the several Constituent Parts of it, as the Springs, Wheels, &c. may, each have their peculiar Attributes, as Bulk, Shape, &c. upon the Account of which it may do several things besides what it performs as a *Watch*: And if the *Effects* of those *Corpuscles* of which Bodies are compos'd are sometimes so Prodigious; as for Instance, the Effects which *Fire* produces by its Heat, we need not wonder that such great things may be done, as we sometimes see by several Active Qualities convening into one Body; since we see Engines perform very strange things, by virtue of those Accidents, *viz.* the Shape, Size, Motion, and Contrivance of their Parts.

Of Generation, Corruption, and Alteration.

VIII. Having thus according to our *Hypothesis* shewed what is meant by a *Form*, it remains that we explain, what is to be understood by *Generation*, *Corruption*, and *Alteration*. In order to which we are to consider,

1. That there are some Particles of Matter so small, that tho' they be *Mentally*, or by Divine *Omnipotence*, divisible, yet are scarce Actually divided by Nature; which in that respect may be call'd *Minima Naturalia*. Considerations requisite to the Doctrine of Generation, &c.

2. That there are Multitudes of *Corpuscles*, consisting of a *Coalition* of several of these *Minima Naturalia*, whose Bulk is so small, and *Adhesion* so close, that tho' not absolutely indivisible into

into the *Minima Naturalia*, yet very seldom are actually divided; and these are the Seeds or immediate Principles of many sorts of Natural Bodies, as Earth, Water, &c.

3. That both the *Minima Naturalia*, and those Primary Clusters resulting from the *Coalition* of them, having their determinate Bulk and Shape; when these are united, the Size and Shape by their *Juxta-position* must be often altered, and oftentimes their Tendency in and to Motion vary'd; which *Accidents* will also happen when they are dis-joyn'd, by which Unions and Separation of Parts, the Size and Shape being variously altered, they are accordingly adapted to several Pores, upon which Account they have different Effects upon several Bodies.

4. That when several of these *Corpuscles* are associated, and put into Motion, that Motion will produce great Alterations, and many new Qualities in the Bodies they compose; as Air swiftly moved, is call'd *Wind*, and feels colder to the Touch; and *Iron* rubb'd against *Wood*, feels warm. But besides these Invisible Alterations, there are several which are visible; as when the Particles, by knocking together, are broke and dis-joyn'd, and by that means acquire new Forms, their Bulk and Figure being altered, and the *Texture* and *Interstices* of the Parts being also vary'd: Thus *Water* froze, acquires Firmness, and loses its Transparency; and *Milk*, by a languid intestine Motion of its Parts, in hot Weather, turns into a thinner Liquor, and into *Cream*, which agitated in a *Churn*, turns to an Oily Substance, and a thin fluid. So *Fruit*, by being bruised, loses its Colour, Taste, Smell, and Consistence: From whence

whence it appears, that *Motion* is not only the Grand *Agent* in Altering, but Composing and Constituting the Forms of Bodies.

5. And that since the Qualities of Bodies are derived from the Size, Shape and Motion, and the Texture, or Essential Modification of the Parts of Matter, we need not deride the Ancient *Atomists*, for attempting to deduce *Generation* and *Corruption* from the *visus* & *disensus*, the *Convention* and *Dissolution*, and their *Alterations* from the *Transpositions* of their *Atoms*; tho' I believe they all three are concern'd in *Generation*, as well as *Corruption* and *Alteration*.

These things premis'd, our Doctrin of *Generation*, *Corruption* and *Alteration* may be compriz'd in a few Words; for when there is such a Concurrence of Accidents as are requisite to constitute any determinate *Species*; such a *Species* is said to be generated; in which Action no new Substance is produced, but that which was *Praeexistens* obtains a new Manner of Existence, or new *Modification*; which is evident in the making of a *Watch*, where the Parts are the same, when separate, as when joyn'd, only the Union in respect of the whole, makes a new Body of a peculiar Modification: And when that Union of Accidents, which denominates a Body generated, is destroy'd and dissolv'd, that Body, losing its Essential Modification, is said to be corrupted; for as a *Watch* is said to be made, when its Parts are put together; so when they are again displac'd, it is no longer call'd a *Watch*.

Hence we may learn to understand that *Axiom*, *Corruptio unius est Generatio alterius*; & e contra; for when those *Accidents* which make one Body,

Generati-
tion, Corru-
ption, &c.
what.

are

are by any means altered, it loses that Denomination, and being modify'd anew puts on another *Form*, and becomes a Body of another Kind.

Putrefaction
what.

And here before we wholly leave off the Consideration of *Corruption*, it may not be amiss to take Notice, That *Putrefaction* is but a peculiar kind of *Corruption*, where the Texture of Matter is more slowly altered, than in *Corruption* in a strict Sense; and also, that all the Essential Qualities are not destroy'd.

Alteration
what.

And here it may be seasonable to take Notice also, That tho' the Form of a Body depends on its Essential Modification, yet it seldom happens, that a Body acquires no other Qualities, than what are essentially and absolutely necessary to denominate its *Species*; since in most Bodies it falls out, that there are some Qualities, which whether absent or not, don't essentially change the Subject; the Acquisition or loss of which is call'd *Alteration* (or by some *Mutation*). *Generation* and *Corruption*, depending on an Acquisition or Loss of the Essential Qualities of a Body.

But to conclude this *Theoretical* Part, let us reflect briefly on the Fruitfulness of this *Mechanical Hypothesis*: For, according to this Doctrine, the World we live in is not a moveless indigested Mass of Matter, but an *Automaton*, or *Self-moving Engine*, whose Parts are most of them in a variety of Motions; and so close set together, as to leave no Vacuities, or very little ones betwixt them. And since the various *Coalitions* of these Parts, are enough to make several Bodies of as various Textures; and we see such a vast variety of Words made only of 24 Letters differently situated, we need not wonder that so many, and such

such multitudes of Bodies should result from Matter differently Modify'd, by a *Coalition* of Matter subject to so many Accidents, as Matter in Motion must be, its Parts being subject to be alter'd variously by the Addition, Communion, or Subtraction of a few Parts of Matter.

CHAP. II.

Further Considerations concerning Particular Qualities.

HAVING said thus much of the *Qualities* of *Bodies* in General, I now proceed to Particulars: And here I shall not spend Time in reckoning up all the Different Significations of the Word *Quality*; since what follows will explain, what Sense we use it in: I shall therefore only in short intimate, That several things have been accounted Qualities, which seem rather to be Complexions of them; as *Inanimal*, *Animal*, *Health* and *Beauty*; the last of which seems to be the Result of *Symmetry* and *Complexion*, with Agreeable and Delightful Colours. There are other States of Matter also, as *Rest* and *Motion*, *Size* and *Shape*, usually call'd *Qualities*, which are rather to be accounted Primary Modes of Matter. But this concerning Names rather than Things, I shall (waving the usual Divisions of *Qualities*) treat of them according to the following Division: *viz.* First, I shall consider them under two Heads; to wit, *Manifest* and *Occult Qualities*; the former of which we shall divide

Primary
Modes of
Matter, and
Complexions
of Qualities
mistaken for
Real Qualities.

B

into

into Three several Classes: Considering under the two last Heads, those *Qualities*, the Knowledge of which is owing to *Chymistry* and *Experiments*; to which I shall subjoyn some, which because they are made use of by *Physicians*, are call'd *Medical*.

But before I descend to *Particular Qualities*, I shall endeavour to remove some Objections made against the *Corpuscularian Notions* of *Qualities*.

An Ob-
jection a-
gainst the
Corpuscu-
lar Philo-
sophy an-
swer'd.

The First is founded upon the Opinion of *Aristotle*, who teaches, That the Diversity of *Qualities* depends on the Difference of *Substantial Forms*; because several of them are not capable of being produc'd by a Mixture of the Four Elements; and therefore, the Learned *Sennertus* argues, That, as a Mixture of Elements cannot, so neither can an Universal *Forma Missionis* account for the *Diversity of Qualities*.

To remove this Difficulty, I shall lay down the following Considerations; having first observ'd, That it is rather an Argument for, than an Objection against the *Corpuscularian Philosophy*. For if the Connection between that Modification of Matter, which affords one sort of *Phænomena*, and that which causes another, be so strict; we may with Reason teach, That whatever modifies Matter after the former Manner, will qualifie it to cause the *Phænomena*, properly belonging to such a Body; and that, that again being modify'd, so as to be chang'd into the other, will likewise produce Effects congruous to that: As Spirit of *Vinegar* will turn Syrup of *Violets* red; yet that Acid Spirit being destroy'd by a Solution of *Coral*, hath a different Effect, and turns Syrup of *Violets* green.

But

But to answer the Objection: First I say, That Compound Bodies are endued with Qualities very different from those, properly belonging to the Separate Ingredients: To prove which, the following Instances are sufficient; *viz.* That Sugar of *Lead*, which is a very sweet Substance, is compounded of Bodies of very different Tasts, as Spirit of *Vinegar*, which is very sowre, and *Minium*, which is as insipid: So likewise *Vitriol* acquires a blue Colour; tho' neither *Aqua Regis*, nor Crude *Copper*, of which it is made, be of that Colour: from whence it is evident, That Mixture is sufficient to produce New Qualities. And *Nature*, as well as *Art*, very often compounds Bodies of Ingredients, that before were Compound Bodies themselves: As when Ashes and Sand are turn'd into Glafs; or Sulphur and Crude *Vitriol*, form a *Marchasite*: And not only so, but sometimes Bodies Decomposed, are again associated, so as to form a third Substance; as when Native *Vitriol* is compos'd of a Saline Liquor, and a Cupreous or Martial Mineral, combin'd with a Sulphureous and an Earthy Body. And it is not unknown to *Artists*, That two pieces of *Ammels* skilfully mix'd in a Flame, produce Colours more primary, than what a Colliquation of them affords. But it will be much more illustrated, if we consider, what a Variety of different Qualities may be produc'd in a Compound Body, by varying the Proportion of the Ingredients, of which it is to be made.

The Qualities of a Composition are different from those of the Ingredients.

Qualities the Result of Mixture.

But Secondly, That the Qualities of Bodies may be chang'd, without the Addition or Recess of other Parts of Matter, meerly by altering the Texture and Motion of the Parts of the Ingredients

Texture and Motion sufficient to alter the Qualities of Bodies.

redients of a Body, is evident; since Water *Hermetically* Sealed, being froze, instead of retaining Fluidity and Transparency, becomes Brittle, Firm, and sometimes Opacous; which Qualities upon a Thaw it again loses. Also fixt Metal, barely by being hammer'd, becomes brittle; which Quality it presently loses, when heated in the Fire. And Silver, by being hammer'd, puts on Qualities, which it by no means had when cold; as a Power to melt some Bodies, and to dry others; with several others, which it only acquires, by Virtue of the invisible Agitation of its Parts, put into Motion, by hammering.

I might add several Instances of this Kind, but having mention'd them in other succeeding Chapters, I shall omit them here; and pass to

The Third Consideration, which hath been prov'd in the preceding Chapter; which is, That we are not to consider the Effects of Mix'd Bodies, as the bare Result of the Parts of Matter of such a determinate Texture; but as plac'd amongst other Bodies, on which they may variously act, and be acted on.

But Fourthly, to remove this Objection, we must consider, That the *Peripatetick*, as well as *Chymical* Principles, are incapable of accounting for the various *Phænomena* of Nature, which the Corpuscular Philosophy hath a greater Advantage in: For neither the different Colours of the Planets, nor the Generation and Perishing of Spots in the Sun, are to be accounted for by the Doctrin of the *Peripateticks*, nor *Chymists*; besides several *Phænomena* relating to *Magnetism*, *Musick*, *Dioptricks*, *Catoptricks* and *Statics*.

And indeed, I should think it not a little strange,

strange, that the various Textures, as well as Motions of Bodies, would not more sufficiently account for the *Phænomena* of Nature, than the Consideration of Quiescent Ingredients; for as all Natural Bodies, act on one another by Motion; so that Motion is variously determin'd, according to the different Textures of the Agents and Patients.

The Difference in Agents and Patients diversify the Actions.

But to proceed to the Second Objection against the *Corpuscularian Philosophy*; which is, That it is impossible, so great a variety of Qualities should arise from so few Principles, as Matter and Motion. In answer to this, I shall endeavour to shew, that it is possible those *Catholick Affections* of Matter, should be deriv'd from Local Motion; and that those Principles being variously combin'd and joyn'd together, should afford *Phænomena*, as various as any to be observ'd in Nature.

A Second Objection against the Corpuscularian Philosophy answered.

And First; If we allow what is undeniable, viz. That the Tendency of Matter, as to Motion, is different in several Parts of the Universe; it will follow, that by *Local Motion* so diversify'd, Matter must be divided into Parts distinct from one another; and consequently, being Finite, must necessarily have a determinate *Size*, as well as *Shape*: And since all the Universal Bulk of Matter, hath not its Parts in a constant Motion, some of them, being intangl'd together, must needs be at Rest. And hence the Primary Affections of Matter flow.

But there are yet other Affections of Matter, belonging to the lesser Fragments of it, in Respect of their Situation, as *Posture*, either Horizontal, Erect, or Inclining, in reference to our Horizon; and also a peculiar *Order*, in Relation to each

The Difference be-
twixt Mix-
ture, and
Texture.

The Phenomena ex-
hibited by the
Corpuscular Princi-
ples very
numerous.

other ; the Union of which Parts collectively consider'd, may properly be call'd *Texture*, or *Modification*. And since most Bodies are made up of Parts something Irregular ; it is impossible but that there should be Interstices, or *Pores* left betwixt them. And further, some Parts of Bodies, being very subtile and fine, and easily put into Motion by Heat, or other proper Agents ; such Bodies cannot but emit good store of *Effluvia*. And when Particles of Matter are fitted and adapted, so as to adhere together, they form those similar Bodies, call'd *Elements*, which being mix'd with one another, constitute Compound Bodies ; which being again associated with Compounds, form Bodies, still more Complex ; which Compounding and Decomposing of Bodies, may be Properly call'd *Mixture* ; which differs from *Texture*, because it implies a Heterogeneity of Parts, which the latter does not. And Lastly, all Bodies, whether Simple or Compound, are to be consider'd, as plac'd in the World, as it is now constituted, and rul'd by *The Universal Fabrick of things*, as well as *the Laws of Motion*.

From hence it appearing, That Matter is very Naturally diversify'd by eleven *Primary Affections*, to which it self being added, makes twelve ; we may by Parity of Reason consider, that if such an inaccountable Number of Words, may be made of the 24 Letters ; it will not be hard to think, that so many different Modes of Matter may arise from such Finite Principles, as could Reasonably be suppos'd to result from the various Associations of those ten Letters.

And indeed, an inaccountable Number more : since every one of these Principles admits of an
Incre-

Incredible Variety. As first, there may be a vast Variety of *Associations* in respect of the *Figure* or Number, or Order of the Parts joyn'd; as in Figure, some may be Triangles or Squares, others Pentagons, &c. There may also another Variety proceed from the Different *Shapes* and *Sizes* of the Parts of Matter united; their Figures being either Spherical, like a Bullet, Elliptical, like an Egg, or Cubical, as a Dye, &c. together with a great many others: Examples of which the Instruments of Carvers, Gravers, &c. afford; those Tools being not only of different Sizes, but also various Shapes. And there is no less Variety in the Degrees of Motion; since Motion may be infinitely different in Swiftneſs or Slowneſs, Uniformity or Difformity; as also, according to the different Lines in which Bodies move, as Streight, Circular, Hyperbolical, Ellyptical, &c. as also according to the differently Figur'd Parts they strike against; to which Causes of Variety, may be added the different Sizes or Shapes of the Bodies mov'd: as also, the ſeveral Degrees of Compound Bodies, and the different Modifications of their Ingredients; and likewise of the *Mediums* through which they move, as well as the Degreeſs of Impulſe. And the Effects of theſe may be vary'd again, according to the different Situation or Determinate Natures of the Bodies they ſtrike againſt.

And, that Motion is able to produce a vast Variety of Effects, we may learn from Musical Instruments; where according to the Difference of the Air's Motion, ariſing from the various Vibrations of the Strings, &c. different Sounds are produced; which, as they are more or leſs co-

Musical In-
struments
afford in-
ſtances of
the various
Effects of
Motion.

incident, cause either Concords or Discords in Sound.

But it would be too tedious to mention all the Diversities which might happen in *Qualities*, by the various Combinations of our Ten Principles; and therefore, since from hence their Fertility may sufficiently appear, I shall proceed to

*A Third
Objection
answered.*

The last Difficulty raised against the *Corpufcular Philosophy*, which is, That if the *Qualities* of Bodies depend on the *Size, Shape* and *Textures* of Bodies, all Bodies of the same Colours must have the same *Textures*; and if the same *Textures*; the same *Qualities* in other respects: But we see it is contrary, since the Calx of *Hartsborn* is insipid, and yet the Volatile Salt of *Hartsborn* is very strong Scented, and of as strong a Taste: To which a great many more Examples might be added were it necessary.

Considerations in order to remove the Difficulty.

But I shall rather, since it is not requisite, offer the following Considerations to remove the Difficulty.

First, That several Heterogeneous Parts may be lodged in the Pores of a Body, which tho' of a different Nature from the Body it self, yet they may produce some considerable Effects; as in Perfumed Gloves, the Odoriferous Parts are both different in Substance, and have different Qualities from the Leather the Gloves are made of.

The Second Consideration is, That Parts of very different Natures may be linked together, not in an Essential Structure, but a Juxta-Position, or Peculiar kind of Composition, and yet afford the same Qualities, notwithstanding their
Essential

Essential Differences ; for invisible changes in some Parts of Matter, may be sufficient to cause new Qualities, tho' the Essential Parts of those Bodies be unaltered ; and not only so, but diversified enough to denominate them of different Species. So a Bar of Iron, by being hammer'd, may feel hot, though there be no visible alteration in the Nature of the Metal by an intense Agitation of the Insensible Parts of it.

But to illustrate this Consideration a little further ; tho' a Piece of Iron, Wood or Tin, should have sharp protuberant Parts, yet are they distinct Substances, notwithstanding they all agree in that Quality of Roughness ; and if those rough Parts were worn off, and the Body endowed with a smooth Quality, yet still would they in respect of their Substance, remain unaltered : And tho' the superficies of Steel, Brass, Flint or Marble should be polished as to become Specular, their Essential Differences would still be the same. And as I took notice before, tho' Air be put into an Undulating Motion by different Instruments, yet if the Motion be raised to the same degree, it causes the same Sound, and produces the same Note. So that Bodies may agree in some Extra-Essential Attributes, and yet be different in their Essential Modifications : To confirm the Truth of which, Heat will afford us an Eminent Example, which may be produc'd in a Body, by putting its Parts into Agitation, without destroying the Essential Properties of the Body so affected : So that the Essential Nature of a Body may not be concern'd in reflecting the Rays of Light, which produce those Extra-Essential

Essential Qualities, which are called *Colours*; since to produce Whiteness in a Body, it is sufficient, that the Surface of that Body be so modified, as to reflect the Rays of Light copiously and undisturbed, whatever the Essential and proper Texture of that Body is.

Different Qualities afforded by Bodies Homogeneous as to Sense.

And here it may be proper to take notice, that there are several Bodies Homogeneous as to Sense, which afford different Qualities; as *Salt-Peter*, becomes fluid and transparent, when briskly agitated in a Crucible; whereas it hath other Qualities when cool, being a hard and white brittle Substance: And the Powder of *Alabaster* being duly exposed to a convenient heat, acquires several Qualities not different from those of fluid Bodies. So *Aqua Fortis* although it be transparent and clear, yet if rais'd in the form of Fumes, it puts on a red Colour.

The Third thing I would propose to remove this difficulty is, what hath been several times hinted before, *viz.* That a Body is not to be considered barely as a determinate Substance, but as a part of the Universe, and placed amongst other Bodies. But

Fourthly, As to that part of the Objection, which questions the *Corpuscular* Principles, in making it appear, why a Body so qualified as to cause whiteness, should have other Qualities which are of no Affinity with it; what hath been already delivered, may be sufficient to remove it, *viz.* That the Extra-Essential Parts may be so qualified, though the Essential Parts be not altered; which we have more reason to believe, since most sensible Qualities are only relative Attributes, and may result from an accidental

cidental Motion, or more than ordinary Laxity or Density of Parts, or some other such like Affections.

To illustrate which, if a Third part of *Venice Turpentine* be evaporated, we may obtain from it a Colophony of a Reddish Colour, which being beaten small, will lose its Transparency, and be turned into a white Opacous Powder; which with a Moderate heat will again be restored to its former Transparency, Fluidity and Colour; into which fluid Body, if one immerses the end of a Quill, something below the Surface, and blows Artificially, it will rise in Bubbles, curiously adorn'd with vivid and lively Colours; and if in that state you take it into your Hands, it is Viscid enough to draw into Strings; and if put into a Triangular Figure, will like a Triangular Glass, yield a variety of Colours: When cold, it is very brittle, and if moderately rubbed, it is endowed with an Electrical Virtue of attracting Straws: The same Phænomena will appear upon managing purified Rosin after the same manner.

Several Qualities exhibited by Venice Turpentine

To this I shall subjoyn another instance, to shew, that a Homogeneous Body, may, by shape or other Mechanical Affections, have different Qualities in respect of our Senses, and the Attributes assigned to it upon that Score: The instance is in Putrified Urine Distill'd, the Spirit of which, when it hath by frequent Distillations been dephlegmed, hath a pungent Taste, and swims in a Phlegmatick Vehicle, being also of a very offensive Smell; whose Salts when freed from the Water, are of a white Colour, and are sharp

Another Experiment of the like Nature tried upon Putrified Urine.

sharp and caustick if applied to an Excoriated Part; besides which Qualities, they likewise make the Eyes water, and cause Sneezing. And in respect of Physick, their Qualities are no less noted, being Diuretick, Diaphoretick, and Specifick in *Hysterick Fits*; when mixed with Filings of Brass, they turn them into a green Colour; yet if mixed with Blew Juices of Plants, they change that Colour for a Green one. They dissolve Copper, yet destroy the Corrosive Virtue of other Acid Menstruums; and precipitate the Copper when dissolved by them: Yet if common Salt be associated with it, this Salt ceases to produce most of the forementioned Effects, and forms a Body very like *Sal Armoniack*: which change may probably depend on the Motion and Shape of its Parts destroyed, since by Evaporating most of the Liquor, I have found the Salt not only much less Fugitive and Volatile than that of Urine, but the Crystals of a different Figure, being like Combs and Feathers. And

These Considerations, together with the Extra-Essential Changes of Bodies, may let us see, that Substances may work variously upon different Senses as well as other Bodies; and those Effects too, may depend on Extra-Essential Changes, which may be wrought in Motion, Shape and Texture, &c. the Essential Modifications of Bodies nevertheless agreeing. So that from what hath been said, the Objection, I hope, will seem^r less considerable, and not so perplexing as some imagine.

And these Three Difficulties I have the rather considered, because they may not only explain, but confirm and illustrate what is deliver'd

liver'd in the Chapter before, concerning *Forms* and *Qualities*; and may also clear and render more Intelligible, some things hereafter to be related.

CHAP. III.*Of the Origin of Forms.*

THE Origin of *Forms*, *Pyrophylies*, is one of the most Noble, yet most Obstruse Enquiries in Natural Philosophy; so that the Wissest of the *Peripateticks*, have either confessed their Inability, or given Explanations of them very insatisfactory. But not to examine all their Various Opinions on this Point, I shall only here briefly consider the Opinion of the Modern *Aristotelians*, having already in our Hypothesis laid down in the foregoing Chapter, our Thoughts on this Subject.

The Controversie betwixt us and the Schools The Doctrin of the Aristotelians considered. is this, *Whether the Forms of Natural Bodies be educed out of the Power of the Matter, and whether they be Substantial Entities distinct from Matter?* That they are not, appears from what is contained in the foregoing Chapters; and therefore what I shall here insist on is, that the Doctrin of the *Peripateticks* is to me *Incomprehensible*; for tho' the Schoolmen make use of an Obscure Distinction, viz. That in producing *Forms*, the Power of Matter is partly *Eductive*, and partly *Receptive*; yet since they deny *Forms*, to exist in Matter; it is hard to conceive how they should

should be educed, before existent : And since the Receptive Power, only enables Matter to receive a Form, how can it help to produce it, when the Form must be produced before the Receptive Power can lodge it ?

It is manifest, that the Body hath a Receptive Power in Relation to the Soul, which nevertheless they allow to have a Substantial Form, yet not educed out of the Power of Matter. It's true, were the Form of a Body a more subtile Portion of Matter, as *Spirit* is of *Wine*, the *Eductive* Power might be considerable ; and signifie the same, as if it were granted, that the Form is but a Modification of Matter ; which would amount to this, viz. That by proper Agents, Matter may be so disposed, as to produce a Body of this or that denomination : As the Form of a *Sphere* may be conceived to exist potentially in a Piece of *Brass* ; because that Metal is capable of being put into such a Form : But this they disallow, because, if it were granted, Forms would be but *Accidents*. And as for the other way of educating Forms out of Matter, as *Spirit* out of *Wine*, that cannot be granted by them ; because, then Matter and Form would be the same Substantial Principle diversified by Accidents.

But they tell us strange things of the Efficacy of the Agent, which works upon the Matter out of which Forms are to be educed : To which it may be briefly answered, That the Agent can only act as a Physical Agent ; and if the Form produced by it's Operation, be a Substance not preexistent in that Matter it works upon, and which constitutes the Body, the Form must either

ther be made of some Parts of that Matter, or created *de novo*; if they allow the former, then the Form is not a Substance distinct from Matter; but if they will not allow it to be made of Matter, it must be *de novo*, i. e. out of nothing; which being granted, Natural Bodies must be produced by Creation and Generation, and not by the latter only; and it's strange if they allow that a Physical Agent can effect that, which Antient Philosophers thought too great to be ascribed to God himself.

And as for these Reasons, what they say of the Origin of Forms, is to me *Incomprehensible*; so, that what they deliver concerning Substantial Forms is irreconcilable to Reason: For though they allow these Forms to be Substances, yet they teach, that they depend upon Matter, both *in fieri* and *in esse*: i. e. they cannot exist out of the Matter which supports them; which is to give them the Name of Substances, but the Nature of Accidents. Nay, these imaginary Forms as much invalidate the Doctrin of Corruption, as that of Generation; for if a Form be a Substance distinct from Matter, it must exist of it self, as the Soul of Man does, when the Body is dissolved: But they assert, that in Corruption the Form ceaseth to exist; by which means they make it an Accident, and likewise contradict what they commonly hold, viz. That upon Corruption Bodies are resolved into their first Principles; since if what they assert of Forms be true, Bodies are but partly dissolved into their first Matter, and partly annihilated or restored to the common Stock of Forms; which, notwithstanding any thing to the contrary, must be immortal.

But

The Aristotelian Doctrin of Forms contrary to Reason.

Arguments
alleged by
the Schools
in defence
of their Do-
ctrin an-
swered.

But to examine some of the most Plausible Arguments brought by the Schools to evince their Doctrin of Forms: First, they argue thus, *Omne compositum substantiale requirit materiam & formam substantialem ex quibus componatur: Omne Corpus Naturale est compositum Substantiale, Ergo, &c.* In which, Syllogism for Brevity sake I shall deny the Minor, because nothing in Nature is composed of Matter and a distinct Substance, but Man.

The Second Argument they bring, is, that if Substantial Forms were deny'd, all Bodies must be *Entia per Accidens*; to which it may be answered, that there is no such Necessity, since Matter, Figure, Texture and Motion, *ordinantur per se & intrinsice*, to make up natural Bodies.

Another Argument which they alledge is, That if there were no Substantial Forms, there could be no Substantial Definitions; which comes to no more, than that if we don't grant some things which are not in Nature, we shall want a Foundation for our Definitions: And indeed if we must define Natural Bodies by Imaginary Forms, which we know not, it is better to exchange *Substantial* for *Essential* Definitions, grounded on the Essential Differences of Natural Bodies themselves.

Their Phy-
sical Argu-
ments con-
sidered.

These Arguments for Substantial Forms being examined, I shall briefly consider the Physical Arguments usually alledged for the proof of them.

The first is, the Spontaneous cooling of hot Water; an Action usually attributed to the Power of the Substantial Form; which might be

be plausible, were it not otherwise to be explained; for Bodies esteem'd cold, having their Parts in a less Agitation than the Natural Juices about the Sensory, cause that Sensation; but when the Parts of that Water, by the heat of the Fire, are put into a Violent Motion, stronger than that of the Parts of Matter about our Sensory, it becomes hot; which hot Water being removed from the Fire, and the Agitation of its Parts being diminished, it returns to its just Temperature: To effect which, a Substantial Form is no more requisite, than when a Ship is put into a violent Motion in a Storm, there is required a Substantial Form to stop its Motion upon the ceasing of that Storm. And in opposition to Substantial Forms, it may be likewise considered, that Water in upper Rooms in hot Climates, will be kept warm, and in *Nova Zembla*, in the Form of Ice, meerly by the Temper of the Air, in spite of the Substantial Form.

Another Argument urged is, that Matter being indifferent to all Accidents, it wants a substantial Form to link the Accidents requisite to every Particular Body together. To which it is answered, that the World being now made and constituted, the Phenomena of Nature depend on one part of Matter acting on another; so that especially fluid Bodies frequently change their States, being altered by the several Seasons of the Year, and Temperature of the Air, which is evident from the different Effects it hath on Weather-Glasses. So that the Accidents observable in most Bodies, depend on Agents and Efficient Causes, which produce in Matter
C what

what in the Precedent Chapter we call an *Essential Form*: And there is no need of a Substantial Form to keep those Accidents together; since they will continue in the same state, till some other Agent works on them, which is strong enough to destroy and change the Texture and Form of that Matter; which Agent, the assistance of a Substantial Form being not able to resist, the Body in spite of the Peripatetick Doctrin must be chang'd; an instance of which we have in Lead, which (tho' when melted, it returns to it's pristine state upon cooling) if it be long continued upon a Violent Fire, will be turned into a reddish brittle Glass, and lose all its former Qualities; and retains those new acquired ones, till some powerful Extrinsick Agent, cause a fresh Change. On the contrary, Oranges, Tamarinds, Senna, and several other Bodies, retain the same Qualities, when gathered and removed from the Soul of the Tree, and without the influence of its Form, which they had before whilst growing: And the colour of Snow soon perisheth, notwithstanding its Substantial Form, its Texture being altered by a Dissolution.

The Parts of
a Body may
adhere
without the
help of a
Substantial
Form.

But there is still another Argument generally alledged in favour of Substantial Forms; which is, that without them, the various changes observable in Bodies, and the adhering of several Parts of Matter united into one *Totum*, would be unaccountable. As to the first Part of this Argument, it is easily answered, since Local Motion variously determined, is able to effect considerable and various Changes in Bodies; an Instance of which (besides what hath been

been said in the first, and the preceding part of this Chapter) we have in Tallow, which by the Mechanical Effects of Fire, exchanges Heat for Coldness, Fluidity for Firmness, and instead of Whiteness, puts on Transparency. And besides the Changes which are caused by the Action of one single Quality in an Agent, as Heat; the Operations of Bodies, proceeding from the Texture of the whole, are various, as appears by Factitious Vitriol, which is made of Iron and a Corrosive Menstruum, yet hath all the Qualities of Natural Vitriol.

And as to the Second Part of the Argument, viz. That the Parts of a Body could not be united into one without a Substantial Form; I answer, That a Connexion of Parts conveniently figured is sufficient; as when a *Pear* is grafted on a *White-thorn*, or a *Plum* is inoculated on an *Apricock*; there is a Union of Two different Forms meerly by a Connexion of the Parts of Matter, and the Parts grafted or inoculated, receive Nourishment as naturally, as if they were supposed to be joined by a Substantial Form, to a Stock of the same Form and Texture with themselves. Another Instance of Union by a Connexion of certain figured Parts, we have in Glass, where the Particles of Sand are linked together with the Saline ones, by the help of Colliquation, and the violent Action of the Fire.

But to conclude; I am not ignorant that it is alledged in favour of Substantial Forms, that they render Natural Philosophy much more perfect, and that it would be very imperfect without them; which comes to no more, than that

if we must not explain things difficult by things unknown, we must be imperfect; where I think the Imperfection is not at all remedied; for should it be ask'd why *Jet* attracts *Straws*, or why *Rhabarb* is a *Cholagogue*, and the Answer should be, by reason of their Substantial Forms; it would be all one as to say, by I know not what, because those Forms are unknown.

Being therefore in things purely appertaining to Natural Philosophy, unwilling to believe what is not intelligible, I shall leave the Doctrine of Substantial Forms, to those that have clearer Heads than my self, and shall rather proceed upon Intelligible Principles.

The Form of
a Body is
its Essential
Modifica-
tion.

I shall therefore briefly intimate what hath been delivered before concerning our Notion of Forms, *viz.* That the Form of a Body is its *Essential Modification*; and tho' Matter at the first Beginning of things, had both Form and Motion from the wise Creator of things; yet now the various Forms of Bodies depend on the Effects of Local Motion, which divides, and variously transposes, and so alters both the Textures and Forms of Natural Bodies, tho' I say, at the Creation, the Parts of Matter were guided by a Supream Power, so as to convene into an orderly and well contrived Fa-brick.

CHAP. IV.

*Considerations concerning Subordinate Forms,
as they are usually held by several Learned
Modern Philosophers.*

IT is usually held by several *Modern* Philosophers, That besides the Specifick Form of a Body, there are several Subordinate Forms in Determinate Parts of it, subservient to that which is the Common Form of the whole Substance; and which, upon the Dissolution of a Body, become Specifick Forms themselves; the Specifick Form which presided over them before, being destroy'd: As when in a Living Animal, the Soul, which is the Specifick Form of that Animal Body is separated from it, the Forms which were before lodg'd in every Part, as subordinate to that, become the Specifick Forms of each Part: But tho' *Sennertus* ingeniously alleges the Specifick Virtues of Plants in favour of this Doctrin, yet we have reason to repute them invalid Arguments; since we see, That several Flowers retain their Natural Colours and Smells, and for ought we can perceive, the same Virtues with which they were endu'd when growing, after they were gather'd.

But since this Doctrin hath been made use of, to corroborate their Notions of *Substantial Forms*; I shall make it appear, that what they attribute to Subordinate Forms, may be explain'd by the Corpuscular Philosophy. In order to which, I shall consider and observe,

*The Notions
of Modern
Philosophers,
concerning Sub-
ordinate
Forms,*

*Considered,
and exami-
ned.*

First, That the *Technical Word Form* is usually made use of, to signify some conspicuous *Phænomena* of a Body, upon the Abolition of which it is said to change, or deposit its Form.

Secondly, That those Parts, or Substances usually held to be the subject of Inhesion to a Subordinate Form, are Organical; and tho' some appear as to Sense Similar; yet are they compos'd of Parts very different: As *Vitriol*, which tho' to Sense it appears to be a Similar Substance, yet it is by Art discover'd to consist of Saline Parts, united with a Metalline Substance: And *Rhubarb*, which instead of that Specifick Form it had whilst growing, according to their Doctrin, exerts its Subordinate or Substantial Form, when laid up for use, retains Virtues, which are different from each other; as a *Styptick* Virtue, when the Purgative is extracted: So that there is no Reason but that it should have Subordinate Forms, agreeable to each of these Qualities, distinct from those which are call'd *Forma Missionis*, by the Schools: But further, we may observe in an *Almond*, which tho' when gather'd, it loses its Vegetative Form; and that which was before Subordinate becomes the Specifick Form of it: yet there is no Reason why we should deny Forms Subordinate to that, since by a bare Pressure, it discovers it self to consist of an Oyl and an Insipid Substance, both of which have Forms distinct from that of the entire Fruit:

Observations to prove Subordinate Forms.

To these, I shall add two Instances more; the first of which is in *Sulphur Vive*, which by being kindled under a Bell, yields oylly Parts which are spent in a Flame, and Saline Corpuscle, which, being condens'd by the Moisture of the Air, adhere to the sides of the Glass, and constitute a

Men-

Menstruum violently corrosive, which will afford a dry brittle Salt. The Second Instance is in *Cinnabaris Fossilis*, which is a Substance compounded of three Forms, very distinct from each other; as that of Mercury, and Sulphur, which is also a Compounded Substance: From all which it appears, that there are in most Concretes, besides the Substantial Forms* of the whole, Forms Subordinate to those, belonging properly to the Parts of those Compound Bodies. But,

Thirdly, That all the Ingredients of a Compound by Uniting, make one Form, upon the Union of which all the Effects of that Body depend, is evident in Gun-powder, the Action of that Compound depending on the Concurring and united Effects of Charcoal, Nitre, and Sulphur: So that

Fourthly, Tho' a Compound acts by Virtue of its Composition, and *ad modum unius*; yet each of its Ingredients retain their particular Attributes, as well as their Modifications, which distinguish'd them from other Bodies before that Composition was made: and this is evident from what some of the *Aristotelians* write concerning the Life of an *Embryo*; viz. That an *Embryo* hath a Vegetative and Sensitive Life, before that of a Man; where the Vegetative and Sensitive Souls, pre-existent to the Rational, are not destroy'd, but only depos'd by the Succession of a Super-added Soul; which become the Specifick Form; from whence it Naturally follows, that there are Forms which in respect of others are only *Preparatory*, and dispose the Matter modify'd by them, to receive a more exquisite Stamp, or a more perfect Form; which, if it be not added, those ruder

A Com-
pound Form
what.

Forms, are nevertheless Specifick in respect of those Bodies they are the Forms of.

*In what
Sense the
Soul may be
said to be
the Speci-
fick Form.*

But tho' I make use of these Arguments, I would not be thought to adopt altogether what these Men teach, having elsewhere explain'd, in what Sense, according to their Doctrin, the Souls of Living Bodies may be said to be their Forms, by observing the Difference betwixt Animating and Natural Forms, as to the Manner of their Informing the Bodies they belong to. As the Soul is not the sole Architect of the Body, nor do the Properties of the Body flow from it, tho' in other Bodies the Compound Form, as well as Qualities, depend on the Forms of the Ingredients of that Body united. And indeed the Properties of a Body are so far from flowing from the Specifick Form, where the Soul alone is esteem'd so; that in Brutes, as well as Plants, several Qualities remain undestroy'd, after the Form is destroy'd; as Shape, Colour, and Vertues, &c.

*In what
the Speci-
fick Forms
of an Ani-
mate Body
differ from
those of an
Inanimate.*

And tho' it be held by some, That there's a *Forma Cadaveris*, that keeps the Parts of a dead Body united, and preserves their Qualities entire; yet, since it is only held as necessary, to support the *Peripatetick* Doctrin, we shall not dispute it; but shall only say, That the Fabrick and Connexion of the parts of a Body, are sufficient to preserve the Pristine Qualities of it from Dissolution, till the Internal Agitation of the Juices breaks that Texture: which is apparent by what hath been observ'd in very cold Countries, as *Russia* and *Sweden*; where the dead Bodies are for several Months kept unburied, and uncorrupted: and in *Aromatick* Plants, there is an undeniable Argument, since after the Vegetative Soul is de-

stroy'd, they continue uncorrupted for several Years.

But to determine whether the Soul be the sole true Form of an Animate Body, is not our Design at present; and therefore I shall only bring an Instance or two to shew, That the Forms of the Simple Ingredients of Compound Bodies are as truly Forms, as those of a Complex Body. The first is, That the Spring of a *Watch* is as truly a Spring before it is made a Part of that *Watch*, as after; and as truly hath its Form: And tho' *Copper* by Corrosive Spirits be turn'd into a *Vitriol*, and consequently the Form of *Copper*, in respect of that *Vitriol*, becomes a Subordinate Form; yet it is as truly one as that of any other Body.

The Forms of the Ingredients of a Compound truly esteem'd Forms.

And tho' *Aristotle* attributes to Forms *τιμότης*, *τιμότης*, *ἐν μίᾳ*, yet it is a Matter of Difficulty to know *ἐν ἀμύᾳ*, what Form is most Noble; since Pearls, which are of the greatest Value, being prepar'd in the Form of a *Magistery*, are of little Value to them that only wear them; tho' by a Sick Man the latter is more to be priz'd.

hard to be determin'd amongst Natural Bodies.

Fifthly, But tho' it be so difficult to distinguish Valuable Forms, from those of less Esteem; yet there may be allow'd some Distinction amongst Subordinate Forms, in as much as some belong to Similar, and others to Organical Parts.

Sixthly, amongst the Parts of Plants, or Animals, there may be some Parts so modify'd, as to put on the Form of Seminal Principles, which upon the Dissolution of that Body, may act as such, in actuating and guiding some Parts of Matter so, as to convene into Insects, &c.

Seventhly, Upon the Dissolution of the Specifick Form of a Body, the Body is to be consider'd

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as beset with other Substances, which may act upon it; as the Sun, Air, or some other Agent; by means of which the Seminal Principles may be put into Action, or new Forms may result, from new Contextures of that Matter.

*Sennertus
his Opinion
agreeable to
the Corpuscular
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These Observations being premis'd, I shall endeavour to shew, That what the Learned *Sennertus* delivers, is agreeable to the Corpuscularian Philosophy.

I agree then with the Learned *Sennertus*, That the Faculties of Plants and Animals, depend not on the *Materia Prima*, and Vegetative or Sensitive Soul; nor on the Form of Mix'd Bodies, consider'd barely as such; but that there is something else requisite to produce that Variety of Effects, observable in *Specifick Medicines*.

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But tho' I allow these things, yet I disallow their Way of Explaining them, as well as a great deal more which they assert; as, That Subordinate Forms act under the Superintendency of Specifick Forms; forasmuch as we may as easily attribute the Effects of a Compound Body, to the mix'd Action of the Compounded Ingredients, as to the Subserving Actions of Subordinate Forms, which united will have an Action in common, and proper to their Complex Modification; it being different from what each of those Ingredients would produce separately. As in a Ballance, the Scale, which by its Specifick Gravity ought to tend downwards, is rais'd upwards, by the Addition of a Weight in the other Scale. So an Arrow, by the Spring of a Bow, is forc'd to flie in a Line, different from what its Specifick Gravity would incline it to, and with greater Violence. And as a Clock, whose Parts

con-

concur to the forming of an Engine, proper to produce such Effects, as usually are produc'd in that Machine, does not act by Virtue of a Superintendent Specifick Form; but the Parts are set on Motion, and move Mechanically by the help of Weights; so, several Subordinate Ingredients, may have a Joynt Effect, each of those Bodies cooperating, and modifying each other's Actions. Likewise Gun-powder, acts not by Virtue of a Specifick Form, superintending Subordinate ones, but Mechanically, by Virtue of the Joynt Effects of its Ingredients; which is evident, since the Effects of the Composition are so different from what the separate Ingredients would produce; and as from hence it appears, that the Efficacy of it depends on its Mechanick Texture; so, to make it appear, that the Ingredients were but slightly mix'd, I boyl'd the Powder of it in Water, and, evaporating the filtred Liquor, obtain'd Crystals of Salt-Petre, the black stuff remaining in the Filtre, being insipid, and inflammable like Sulphur: And this black Matter being boyl'd in a strong Lixivium, so as to dissolve the Sulphur, the Sulphureous Liquor will run through a Filtre, leaving the Charcoal behind; into which Liqueur if an Acid Spirit be dropp'd, the Sulphur precipitates in the Form of a white Powder.

But to illustrate our Doctrin of Forms and Qualities a little further, I shall add, That a blue and yellow Powder being mix'd in a just Proportion, produc'd a green Colour: which did not happen, because those two Ingredients were subservient to a Predominant Form; but because they both being joyn'd made a Compound Impression upon

as beset with other Substances, which may act upon it; as the Sun, Air, or some other Agent; by means of which the Seminal Principles may be put into Action, or new Forms may result, from new Contextures of that Matter.

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Subordinate Forms are not under the Superintendency of the Specifick Forms. But tho' I allow these things, yet I disallow their Way of Explaining them, as well as a great deal more which they assert; as, That Subordinate Forms act under the Superintendency of Specifick Forms; forasmuch as we may as easily attribute the Effects of a Compound Body, to the mix'd Action of the Compounded Ingredients, as to the Subservient Actions of Subordinate Forms, which united will have an Action in common, and proper to their Complex Modification; it being different from what each of those Ingredients would produce separately. As in a Ballance, the Scale, which by its Specifick Gravity ought to tend downwards, is rais'd upwards, by the Addition of a Weight in the other Scale. So an Arrow, by the Spring of a Bow, is forc'd to flie in a Line, different from what its Specifick Gravity would incline it to, and with greater Violence. And as a Clock, whose Parts

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upon the Eye. And likewise in making Sublimate or Vitriol; all that is requisite to enable them to produce Effects proper to such Bodies, is, that the Parts should be in a proper manner context'd and modify'd together; and then, they are not only capable of performing what is usually ascrib'd to them, upon the Account of their more specifick properties; but some, which are not different (as Vomiting, and Purging, &c.) from those Effects, which are said to be produc'd upon Vegetables, upon the account of a Superintendent Form.

*Neither are
the Actions
of Com-
pounds
wholly to be
attributed
to their
Union.*

So that tho' the Operations of Compound Substances depend on the United Texture of Subordinate Forms, yet, as I have before taken Notice the Actions of those Bodies, are not wholly to be attributed to their Union; since upon the Dissolution of that Contexture, each Body hath its determinate Form and Virtue; as when the Ingredients of Gun-powder are again separate; or as when a Rose loses its Specifick Form, by being taken from the Tree: But,

*The Modi-
fications of
Bodies two-
fold.*

To conclude this Discourse, we shall again take Notice of what we have before hinted at in the beginning, *viz.* The unfixt use of the Word *Form*, and that a Body is said to be of this or that Form, upon the Account of a very few Qualities: If then the Form be nothing but a *Congeries* of Accidents, it may, by proper Agents, lose that Form, the Subordinate ones still remaining undissolv'd; till a more powerful Agent destroys them too: (so that a Body may have a twofold Modification:) As for Instance, The Spring of a *Watch*, may, by being put into the Fire, lose that Elastick Virtue; yet nevertheless the Sub-
stance

stance is Iron, and retains Qualities proper to such a Substance. Again, another Instance we have in a Rose, which when it hath lost its Faculty of receiving a Nutritious Sap from the Tree, yet it retains other Qualities, which depend on the Texture and Modification of its solid Parts, the former being only Qualities, in respect of the Specifick Form; but the latter, the Result of its Contexture.

To illustrate this Notion a little further, I shall make use of the following Comparison, *viz.* That as a *Mill*, which is an Organical Machine, performs what belongs to it as such, as long as it is supply'd with Water; so a *Plant* is enabl'd to effect several things, whilst actuated by a Vital Spirit: And further, as a *Mill* upon the Consumption or Congelation of that Water, still retains the same Parts it had before, so do the Parts of a *Plant*, tho' the Soul ceases its communicative Virtue. And to continue the Parallel further, as the Constituent Parts of a *Mill* are not destroy'd, tho' the Faculty of Operating as such be lost; so neither is the Water, but only by reason of Congelation, or Evaporating in the Form of Exhalations, ceases to coexist in a Form fit to turn the *Mill*: So tho' a *Plant* or *Flower* be lopt off, and retains the same Texture of its solid Parts, yet when it ceases to be water'd with a continual supply of Sap, the Sap is only dispers'd in the Air, or intercepted, and spent in some other Part of the Tree: From whence it appears, that nothing at all perishes, but only the Manner of Union, and the Particular Modification of those Parts of Matter cease; so that those solid Parts are no longer fitly adapted to be nourish'd by those

those Fluids. Which Instance may serve to illustrate our Doctrin, tho' there be considerable Difference betwixt the things compar'd, inas-much as a *Plant* hath not always that Aptitude to be again actuated as the *Mill* hath.

But there are some Instances, which may render the Difference less considerable, if we consider that the *Rose of Jericho*, which tho' for several Years gather'd, and wither'd, is so far refresh'd by Water, as to seem but lately gather'd: And I have observ'd, that tho' a *Plant of Aloes* had several Years hung near the Ceiling of my Chamber, yet it was by the use of a convenient Liquor, so far renew'd, as to perform several things, which are usually the Effects of Life and Growth. And the like is confirm'd by what may be experimented in *Wasps*, which, tho' drown'd in Water, will yet recover Life by the Heat of the *Sun*.

The Qualities of a Body whose Specifick Form is destroy'd, depend not on the United Action of the whole Ingredients

But to wave needless Illustrations, I shall proceed to observe, That tho' a Body hath laid down its Specifick Form; yet the Qualities remaining, are not always the Result of the united Subordinate Forms; but depend sometimes on the determinate Forms of Particular Parts of that Body, tho' the Union be such as to preserve the Structure, as to Sense, unalter'd; as appears when an Extract is drawn out of *Rhubarb*, or the Juice of Oak-Bark is extracted by Water, the Remaining Substances, tho' as to outward appearance the same, retain not their Specifick Virtues. Besides, upon the Abolition of Specifick Forms, several new Qualities may be added to a Body, which it had not before, by the Influence of external Agents: As when *Musk* results from the Action

New Qualities may be added upon a Dissolution of a Specifick Form.

Action of some External Body upon Flesh: For not only the Seminal Rudiments, *latent* in Bodies that have undergone a Change, exert themselves; but several outward Agents, to which those Bodies are expos'd, do, by agitating and altering the Textures of that Matter, promote such a Favourable concurrence of Circumstances, that Noble and very Exquisite Forms, may result from their Union and Contexture. As a Lime-Stone, being Physically chang'd by the Influence of Congruous Particles, when expos'd to the Air, will yield *Salt-Petre*, genuine and inflammable. And I have often observ'd an Efflorescence upon certain *Marcasites*, agreeable in both Colour and Taste, as well as other Operations, with *Virriol*, which could be nothing but the Effect of outward Agents, changing the Texture of those Parts, which lay open to the Air for some time.

But to wave these things, I shall illustrate a little further, what I just before hinted concerning a twofold Modification of Matter, *viz.* the Relation it hath to a Specifick Form, and that which is the meer Result of Texture amongst its own Parts: what I shall offer, is, That some things are attributed to the Soul or Specifick Form, which may be effected by the meer Subordinate Association of Parts, promoted by a mutual Concurrence of Natural Agents; as the Excrements may be voided when a Man's dead, or Fruit may be ripen'd after it is gather'd, without the assistance of the *Expulsive* Faculty of the Soul in the former, or the *Perfective* in the latter. Agreeable to this, the Inquisitive *Oviedo* relates a Story to the Emperor *Charles* the Fifth, of a
Fruit

The Modifications of a Body may be twofold, first in respect of the Specifick Form, secondly in respect of its own Parts.

Fruit in the *West-Indies*, call'd *Anana's*, which are gather'd as soon as One is ripe, the rest being kept in Chambers to acquire Maturity afterwards. And the Learned *Josephus Acosta* relates the following Account of the Fruit of a *Plane-Tree* to the same, *viz.* That they usually gather it when green, which being laid up in a Vessel mix'd with a certain Herb, gradually ripens. But the Diligent *Piso* tells a Story, more to our Purpose, of those *Brasilian Plants*, call'd *Pacoeira*, and *Bananiera*; for concerning the Fruit he says, *Continentur plerumque in Uno Ramo, quatuordecem aut sedecem numero, ut ita una Planta, proferat septuaginta aut octuaginta, qui subinde Virides avulsi, nunc in Aedibus, nunc in Navibus suspenduntur, donec justam maturitatem & flavedinem consequantur*: And he also says of the Boughs, when lop'd off, *Ramus autem ille fructibus onustus, interea dum illi maturescunt, augetur, floresque semper protrudit, ex corpore illo foliaceo, &c.* And it is not less remarkable, that *Onions*, and such like Fruit, as well as *Potatoes*, will shoot of their own accord, tho' suspended in the Air.

But not here to take Notice how far these things may result from the Exertion of Latent and Seminal Principles, I shall rather observe, That several things usually ascrib'd to the Soul, may result even from the Texture of the Body, concurring with external Causes; as the Hair, or Nails will grow considerably for a long time, after the Body is dead.

* A Cessation of Vital Functions upon Death, no Arguments of the Soul's Superintendency whilst living.

* And tho' by the Espousers of *Sennertus* his Opinion, the Cessation of the Vital and Animal Functions upon Death, are look'd upon as strong Arguments, That the Soul is the Agent, which effects

effects whatever is acted in the Body ; yet I conceive it depends on somethings very precarious ; since notwithstanding what is manifest to us, the Cessation of those Faculties may depend on the internal Organization, which may in some measure be destroy'd ; Since the Body consists of Parts, not only solid, but soft ; as the Brain, and also liquid, as the Humours ; a right and convenient Coaptation of which is required to preserve Life, considerable Changes in the Humours, being enough to obstruct Circulation, on which Life so much depends. Thus in *Palsies*, tho' there be no visible Change ; yet by an Indisposition, either in the Humours or Vessels, the Parts become void of Sense as well as Motion : And even Sleep it self, so alters the Disposition of our Bodies, that Odours and Sounds are not perceiv'd by a sleeping Man, tho' nothing externally obstructs the Operation of the Soul, which lodges in the Body ; and what considerable Alterations in the Humours may be effected, without our Perception, may be urg'd, from the Effects which Thunder hath upon Wine, in turning it into a Vinegar, sower and uninflamable.

But to render what I have said of Subordinate Forms, more intelligible, I shall lay it down in certain Propositions, without making long and tedious Excursions, applying it chiefly to Inanimate Bodies : And first I shall consider,

I. That the signification of the *Technical Word Form*, is indeterminate ; since it is not agreed what is enough to determine, what Forms Bodies are of ; It being not only disputed, whether Water, by being froze, loses its Form or not ; But further, several Bodies have no particular

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Forms

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Doctrin of
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nate Forms,
apply'd to
Inanimate
Bodies.*

Forms assign'd to them; as Ink, Gun-powder, Beer, Coal, &c. Nay, some Bodies consider'd in different Respects, may seem to have more Forms than One, as in *Vitrum Saturni*, which is made of Lead, it may be doubted, whether it hath the Form of a Metal or Glafs; since it hath a great many of the Qualities of Both, as Fusibility, Transparency, and Brittleness; and will, contrary to common Glafs, dissolve in *Aqua Fortis*, yield a sweet Solution, and may be reduc'd into a Malleable Lead by Fire; so likewise Amel, whose Ingredients are calcin'd Tin, together with Salt and Sand, and some burnt Copper, will again yield most of the same distinct Ingredients; yet the Compound had not all the Properties belonging to these Bodies. But,

The Nobleness of Forms, hard to be distinguish'd.

II. It is a Matter of Difficulty to determine the Nobleness of Forms.

This is not only evident from Examples before given, but several others; as Glafs of *Antimony*, is more apt for some uses than Crude *Antimony*, and *vice versa*. Again, it hath been formerly a Dispute, and may be a Doubt still, Whether the Powder resulting from Gold and Silver precipitated, be a Nobler Metal than Gold; of which were a *Spagetical Physician*, and a *Goldsmith* to judge, the *Former* would value the Powder, as much as the *Latter* would the Gold. Again, tho' Silver Soder be the Result of Silver, alloy'd with Copper or Brass, and of very great use; yet it may be question'd, whether it is not by that means render'd less valuable. And tho' a Plant be petrify'd, and for that reason valu'd as a Rarity; yet is that New Form in it self less Noble than the former.

III. Tho'

III. Tho' several Alterations are made in Bodies, by a Recess or Access of Qualities, yet they retain the same Denomination, and are said to have the same Form, by reason of some Eminent Quality or Use; which is proper to them.

*The most
Noted Qua-
lities of a
Body, deno-
minate its
Form.*

For which reason *Vitrum Antimonis* is call'd so, because it hath the Fusible and Transparent Qualities of Glass; tho' it, in other Respects, besides its Vomitive and Purgative Properties, hath Qualities different from Glass. So all Unctuous Bodies, as Oyl of Almonds, Olives, &c. are call'd *Oyls*, because Fluid, and not apt to be mix'd with Water; yet there is a great deal of Difference betwixt them, and *Empyreumatical* Oyl of *Guajacum* or *Box*: So likewise several Substances of very different Effects, are reckon'd amongst *Salts*; because they readily dissolve in Water, and are very sapid; so that the Word *Form*, seems to be apply'd to Bodies on the account of some *Metaphysical Conceptions*, and in respect of some General Use; rather than *Physical Forms*, by which Substances of the same Form, are said to be of the same Specifick Nature and Virtue. From whence it may be thought that several Substances are generally Class'd together, as they are alike States of Matter, rather than agreeable Forms: As Water and Wine may be turn'd into Ice, or Tallow and Mineral Concretes, may become of the number of Substances which constitute Flame.

IV. That by Compound Bodies, several Effects will be produc'd, upon the account of the Union and Joynt-Action of their Ingredients.

The Action of several Compound Bodies depends on the Union of their Parts.

These Operations, by the Schools, are said to be done *Actione Communi*; as when a Man disputes *vivâ voce*, the Rational Soul concurs with the Vocal Organs, to the Forming of *Syllogisms*: Or, to use a plainer Instance, as a Bullet acts on a Plane, by Virtue of its whole Specifick Gravity, tho' it touches the Plane but in a Point; the other parts acting on it by the Intervention of that: Or as in a Pair of Scales, the whole Substance of a Man, and all that he hath about him, presses upon the Scale, tho' he touches it but with his Feet. But to use an Instance of the Concurrent, or *Actio Communis*, of an Organical Body; the Effects of a Compound Body, are like that of a *Watch*, where if any Part be wanting, the Complex Action so much depends on the Common, and Joynt-Action of the whole, that the Action of the whole is destroy'd.

Inanimate
Bodies have
Subordi-
nate Forms.

V. It is agreeable to Reason, to admit of Subordinate Forms, in Bodies Inanimate.

Against this it is objected, That one Body cannot have two Forms. To this it may in short be answer'd, That tho' a Body can have no more than one *Adequate Form*; yet being a Compound, it may have several, which are Subordinate to, and Parts of that; as the Parts of a *Watch* have each their own Forms, which are Subordinate to the Form of the whole.

A Second Objection is, That a Body having a Compleat Form, whatever is Concurrent to it, makes it *Ens per Accidens*. To this it may be answer'd, That according to the Schools, the Soul and Body, which have each separately distinct Forms, being joyn'd, make *Unum per se*, and not *per Accidens*; and the Rational Faculties, which
are

are its *Accidents*, are said to make *Unum per se*: So that thence, by Parity of Reason, tho' a Congeries of Accidents, concur to the Forming of a Body, yet the Operation and Property of the whole United, being one, it may as well be said to be *Unum per se*. Add to this, that the *Peripateticks* have not scrupled to teach, That the Forms of Elements, are not destroy'd by being mix'd, yet they hold each of the Bodies made up of them, to be *Unum per se*.

But it may be further answer'd, That tho' a Form be compleat in it self, yet the Form resulting from the Union of another with it, may be far more Noble, and perform things much more curious than before: As when Sulphur and Nitre are added to Charcoal; or when a Spring is added to the other Parts of a Watch, where by the Addition of these Forms, the pre-existent are not destroy'd, but improv'd; the whole, in each Composition, making one Compound Form.

VI. Sometimes a Superadded Form is Accidental to a Pre-existent; yet it modifies the Operations of it, without altering its Nature.

A Super-added Form may modify the Actions of Subordinate ones, without destroying them.

As a Needle, which hath its Form consider'd as Steel, besides its Figure as a Needle, and by being touch'd with a Load-stone, acquires several other Properties; as to attract others, and instead of its Indifferency to move any way, regulates its Motion, so as to point North and South; of which Properties it is again depriv'd by being drawn upon the Pole of a powerful Load-stone.

But that we may more clearly understand, how a Superadded Form modifies the Actions of a

Body, we need but reflect on the Parts of a Watch, from whence the *Forma Totius* proceeds; where we may see, how the Spring, by being bent, acquires a Tendency to expand, and how the Wheels moderate that Expansion: From whence we may gather how the Parts of a Body, which united, make the *Forma Totius*, concur in super-adding several New Qualities to the whole. So a piece of Lead is Vitrify'd by the Action of the Fire, by which Action the Parts, which before were pliable, become brittle; and being otherwise rang'd as to Situation, give way to the Rays of Light, and becomes Transparent: And *Salt-Petre*, by the Addition of Coal and Sulphur, instead of burning by degrees, and leaving an *Alkalizate* Salt behind it, flashes all away at once.

Compound
may act
by Vir-
tue of one
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dient.

VII. Besides the Actions of a Body, which are specifick, in respect of the whole; it may have several Operations depending on the separate, and particular Properties of an Ingredient.

This may appear from what hath been deliver'd above: But to make it more clear, I shall again intimate, what hath been before deliver'd, *viz.* That the Parts of a Watch, retain several of their Pristine Qualities, when put together, as they did before: To which another Instance might be added, from what is elsewhere said of Gun-powder. To which it may be added, That several Ingredients in *Physical* Compositions, retain their own Qualities, tho' the Composition hath in General a Particular Effect upon the account of its Mixture. As for Instance, *Ambergreece* retains its Smell, as well as *Aloes* its Taste,

Taste, when made up into Pills with other Ingredients; and *Opium* likewise its *Soporifick* Qualities, tho' mix'd with so great a number of Ingredients as those of *Venice-Treacle*.

Another Example we have in the Precipitate of *Gold* and *Mercury* by Heat, which tho' it hath a red Colour, different from both the Ingredients, yet the *Mercury* retains its *Salivating* Faculty.

VIII. That is often call'd the *Specifick Form* in several Natural Bodies, which is not the Presiding, but only the most Eminent.

The most noted often esteem'd the Specifick Form.

To prove this, we are to consider, what hath been already observ'd: As First, That the Signification of the Word *Form*, is made use of *Arbitrarily*, and without sufficient Distinction. Secondly, That *Forms* are only *Respective*, and the Result of a Determinate Coexistence of the Parts of Matter. Thirdly, That they are attributed to Bodies, upon the account of some particular Qualities; as Unctuousness in Oyls, &c. or some particular Use. Pourthly, Agreeably to these, a Body must be endued wick several of those Qualities, upon the Account of which Bodies are referr'd to different Classes. As in *Vitrum Antimonii*, in which besides those Qualities by which it is referr'd to Glass, it hath a Vomitive and Purgative Faculty, by which it is brought into another Class in *Physick*. Fifthly, It is not requisite, that these Forms should depend on one another; since neither the Vomitive nor Purgative Faculty depend on the Form of Glass, they both being inherent in the *Calx*, before it was Vitrify'd, and would be preserv'd, tho' the Glass, without an Addition of other Matter, should be turn'd into a *Regulus*. Sixthly, To these Observations,

vations, we may add, That the Qualities of Bodies, are said to be less or more Noble, in respect of their different Uses: As in Glafs of *Antimony*, tho' the Glafs may be taken for the Noblest Form by an Artist, yet its other *Antimonial* Qualities are more Eminent amongst *Chymists* and *Physicians*. Seventhly, From these Considerations we may gather, that the most Predominant Form is not always that which denominates the Form of a Body; but sometimes that which is most Eminent, *that is*, most regarded.

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IX. The *Forms* just now mention'd, are rather to be esteem'd Concurrent, than Subordinate.

And indeed, where the Denominating, or most regarded Form, may be so vary'd, they rather seem Concurrent than Subordinate, in respect of the Body, whose Attributes they are.

So that the Subjection of some sort of Forms, seems very difficult to be explain'd. And indeed we are so apt to mistake Names for Things, since by only denominating some Bodies, which have Particular Operations, we are apt to attribute what is the sole Effect of Modification, to that *Metaphysical* Conception, which we have of an Aery Form, rather than to the Body consider'd as a *Physical* Agent, endued with a *Mechanical* and Adventitious Texture. And it is so far from Appearing that there is any thing of Supereminency, or Dominion of one Form in all the Operations of a Compound Body, that in some Simple Bodies, the Specifick Form is not in the least concern'd in the Effects of them; as Water will scald by Virtue of its Adventitious Heat, which is contrary to those Qualities attributed to
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its Form as such. And so Springiness may be added to, or taken away from *Silver*, without altering the Specifick Form of the Metal; nor does the Form of a File, consider'd as Metal, affect what is attributed to it, upon the Account of those Asperities: Nor is the more than usual Hardness the Product of the Substantial Form, but an acquir'd Temper given it by the *Smith*.

It would be an easy Matter to add several other Instances: But to conclude; Tho' the uncertain Signification of Terms, hath made the Foregoing Discourse the more Difficult and Dark; yet I hope it may serve to detect some receiv'd Errors, and promote a truer *Theory* concerning these Matters.

CHAP. V.

Experiments and Thoughts about the Production and Reproduction of Forms.

IT was not without Grounds that I intimated in the preceding Chapter about *Qualities*, that Bodies are in a great measure distinguished into several Species by a sort of Tacit Agreement; there being as yet, no Diagnosticks sufficient to distinguish the several Species of things, but they are rather taken for distinct Species, by being known by such Names, than any true Characteristicks. As for instance, some well skill'd in the Writings of *Aristotle*, hold, that Water and Ice are not esteemed distinct Kinds of

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of Bodies, they both having the same Nature; yet *Galen* not without Reason, favours the contrary Opinion, since they differ both in respect of Fluidity and Firmness, as well as Transparency: Besides, Ice and Salt beaten together, will freeze other Liquors, whereas Water and Salt will not; where there seems to be difference enough to denominate them Two distinct Species of Bodies, as well, as that Must, Vinegar, Wine, Spirit of Wine or Tartar, should be esteemed so; or that a Chick should be thought different from the Egg which was hatched. Yet some *Aristotelians* have been very doubtful whether the Natures of them be different or not, as also whether Clouds, Hail, Rain or Snow differ in Specie from Water, tho' the Writers concerning Meteors usually treat of them as different.

And if so small an Accident as Motion, or whatever distinguishes Wind and Exhalations, is enough to entitle them to distinct Species of Bodies, a Greater Right may be presumed that Paper and Rags, Glass and Wood-Ashes, should be esteemed so too; as also Soap, Sugar, Gunpowder, &c. For it is not a sufficient Objection that most of these Bodies are Factitious; for the present state of a Body, denominates its Species, however it came by that Nature; as the Salt which is made in the *Isle of Man*, by the Sun acting upon the Sea-water, is as much Salt, as that which is artificially made by the Heat of the Fire, by boiling Sea-Water in Chauldrons; and Silk-Worms and Chickens hatched by the heat of Ovens or Dunghills, are equally as much Silkworms or Chickens, as those produced

duced by the heat of the Sun, or warmth of a Hen.

Besides, the Objection, that most of the fore-mentioned Bodies are Factitious, is less valid, since they seem equally performed by Nature, the Artificer being only concerned in putting Natural Agents together, which take the same Measures in causing their Effects, as if they had casually been brought together by Chance: As in Chymistry, the Agent which is Fire, operates upon the Subjects it hath to work upon as Fire, and not as it is barely an Instrument of a Chymist; and therefore tho' the Application belongs to the Chymist, the Action is as much Natural, as the Productions of *Aetna* or *Vesuvius*; where by the internal Action of the Fire, Stones are Calcined, and Metals not only colliquated, but Metalline Flowers and Ashes dispersed about the adjacent Parts.

*The Pro-
ducts of
Art, the
Effects of
Nature.*

And I am not without Probability inclined to believe, that several Minerals as well as other Bodies, which lie near the Center of the Earth, are rather the Productions of Subterranean Fires, changing the Textures of other Bodies than that they have lodged there, since the first Creation of things; for we see, that Lead becomes Minium, and Tin Tutty, in a very small time, and the Fumes of Sulphur, uniting with those of Mercury, convene into that delicate red Mass called Vermilion, which hath so far the similitude of a Mineral, that it hath been called by the same Name of *Cinnabaris*: So that we may easily conceive, how in the Bowels of the Earth, certain Mineral Fumes penetrating and uniting with a stony Concretion,

tion, Minerals may be formed: From whence it may appear, that a Congeries and Union of Accidents, is as sufficient to discriminate the several Species of Bodies, as the imagination of Substantial Forms.

The Artificial Production of Vitriol, correspondent to the Natural.

But to illustrate the Mechanical *Origin of Forms*, we may take notice of the Artificial Production of *Vitriol*, which is so like the Natural, that it makes us able to guess what Measures are taken in the Natural Production of it. And since *Vitriol* is not a meer Salt, but rather (to use a Chymical Term) a *Magistery*, it is requisite to observe, that according to the sense of that Word, it is not prepared by a Separation of Principles, but by the changing the Form of a whole Body, by an Addition and intimate Union of a Saline Menstruum: Agreeable to which Notion it is to be noted, that an Acid Spirit, and a Metalline Substance, may be drawn as well from Artificial as Natural *Vitriol*; and consequently both must be equally natural *Vitriols* in the strict sense of that Word.

But these are not the only Characteristicks of the Natural Agreement of Factitious and Natural *Vitriol*; since *Vitriol* of *Mars*, whether prepared by Oyl of *Vitriol* or Spirit of Salt, hath both the Colour, Transparency, Brittleness, aptness to Fusion, and Styptical Taste, with the *Vitriol* of *Marchasites*; as also several other Qualities, as to turn an Infusion of *Galls* into *Ink*; a Vomitive Faculty, when taken in a small Dose; as also to be endowed with Crystals of very Curious Figures, and a Disposition to run *per Deliquium*, as *Guthernus Belichini*

Belichius hath observed common *Vitriol* made use of in *Germany* to have.

And here we see, that the same Qualities may arise from the Union and Association of Two Ingredients, which are to be found in Common *Vitriol*; without the Incomprehensible force of Imaginary Substantial Forms, or a Generation of a Form distinct from the Ingredients and their Essential Modification; or a Texture of Parts of convenient Shapes and Sizes: Neither is there such an Intimate Mixture, as the Schools imagine, of these Two Ingredients, but a Juxtaposition and new ranging of their Parts in respect of Order and Position: Which is evident, since by Distillation the greatest part of the *Vitriol* may be drawn off, leaving the Metalline Substance behind; and that most of its Qualities depend upon the Position of its Parts is plain, since through a good Burning Glass, the Sun Beams will so alter their Order and Texture as to turn it red.

CHAP. VI.

Doubts and Experiments, concerning the Curious Figures of Salts.

The Figures
of Salts so
be account-
ed for, with
the help of
a Plastick
Power.

THO' I am not willing to acquiesce in the Doctrin of *Substantial Forms*, since to me they are *Incomprehensible*; Yet I am as forward to own, That I acknowledge the Admirable Wisdom of our *CREATOR* no less, because He hath thought fit that the Changes and Alterations in Matter, should depend on Accidents easy and intelligible, at least with less Difficulty to be conceiv'd, than the incomprehensible Doctrin of *Substantial Forms*: And tho' the Curious and Delicate Shapes of *Salts*, be Generally us'd as Arguments of the Great *Plastick Skill* of *Substantial Forms*; yet I must own, I think them very slight things, compar'd with *Organiz'd Bodies*; and therefore I would not have it inferr'd, That because the *Figures* of *Salts* may be accounted for, without the Assistance of *Plastick Powers*, that therefore the Bodies of Animals may.

That *Substantial Forms* are not necessary to the Production of those Curious *Figures* in *Salts*, I am induc'd to believe; First, Because a *Concrete* of no less Curious Figured Parts, than other *Vitriols* may be made by a bare Connection of *Metalline* and *Saline Bodies*. Secondly, because according to the different Quantities of *Liquor*, or the space of Time they shoot in, their *Figures* vary: According to which *Agricola*, lib. 12. p. 462. de re *Metallica*, speaking of the *Cords* that are immerg'd into

into *Vitriol-Water*, for the *Crystals* to stick to, says, *Ex his pendent restes lapillis extenta, à quo Humor spissus adhærescens densatur, intranslucentes atramenti sutorii, vel cubos vel acinos, qui Uva speciem gerunt.*

I remember also, that having a long time thought that the Method usually taken in preparing *Alkalyes*, such as *Salt of Tartar*, &c. was the reason, why they are gather'd in the Form of *Calx*; I took care to dissolve *Alkalyes* well purify'd in Water, slowly evaporating it, till crusted over, with an Icy Crust; which being preserv'd entire, lest they should want a sufficient quantity of Liquor, to give them liberty to move, in order to their more Curious and Congruous Coalitions, I continued them in a moderate Heat for some time, and then breaking the Crust, I had a variety of figur'd Lumps of *Crystalline Salt*; transparent, and not much unlike white *Sugar-Candy*.

Likewise having several times distill'd Oyl of *Vitriol*, and a strong Solution of *Sea-Salt* together, till the Matter left behind was dry; that Salt Substance, when dissolv'd in Water, filtrated and evaporated, would shoot into Salts, of Figures differentr, according to the various Proportions of the Ingredients; yet nevertheless tho' sometimes in the same Glas the *Salts* would be of different Figures; yet would they be more exquisitely figur'd, than those of *Vitriol* often are. And from a Mixture of Spirit of Wine, and Spirit of Nitre, digested long together, I have got *Crystals* much like in shape to *Crystals* of *Salt-Petre*; and I have obtain'd Plates of *Crystals*, made up of solids, very curiously shaped,

Crystals obtain'd from an Alkaly.

From Oyl of Vitriol, and a Solution of Sea Salt.

From a Mixture of Spirit of Wine, and Nitre.

and

and so congruouly adapted, as to make a very plain Surface, much different from what I have elsewhere mention'd from a Solution of *Silver* in *Aqua fortis*, or Spirit of *Nitre*; when I have order'd it so, that it should shoot leifurely.

Thirdly, I have several ways made it appear, That Insensible Parts of Matter of various, tho' very curious Shapes, guarded with plain as well as smooth sides, will convene into Bodies differently shap'd. And tho' Blood, Urine, and Hart's-Horn, might probably have their Substantial Forms destroy'd by the Fire; yet foras-much as the *Saline* Parts, with which they are impregnated, are of the Figures just now mention'd, in the Liquors they have been expos'd, to shoot leifurely; I have observ'd several Masses, the surface of some of which were Plains, very curious and delightful, and the Figures of others exactly Geometrical: And stillatious Acids, as well as the Bodies they are appropriated to ~~dif-~~
~~shoot~~ ~~solue~~ into *Crystals* variously figur'd, according to the Nature of the *Menstruum*, or the Bodies it works upon; as I have experienc'd with a *Menstruum* which would dissolve *Gems*, and likewise with *Coral* dissolv'd in Spirit of *Verdigreece*: For which Reason, when I try'd whether the Shapes of the Particles of *Silver*, dissolv'd in *Aqua fortis*, would dispose them, without a *Coagulation* with *Salts*, to shoot into smooth and flat Concretions; I observ'd, that Part of the Solution being diluted with distill'd Rain-water, and a Copper-Plate immers'd in the Liquor, after it had remain'd there a while, Clusters of Metalline Bodies, devoid of Transparency settled about it, joyn'd together in Plates very thin, yet very glossy

Salts obtain'd from a Solution of Copper.

glossy and flat, the Edges of the largest, being prettily shaped.

And that the Particles of *Gold* are apt enough *From Gold.* to associate with Congruous *Salts*, and to compose Bodies of determinate sizes, I have observ'd in *Crystals*, afforded me by *Gold*, dissolv'd in *Aqua Regis*, and being preserv'd in a cold place, till the superfluous Moisture was evaporated: And from the Parts of *Gold* divided by a stronger *Menstruum*, so minutely as to be capable of being sublim'd, I have obtain'd *Crystals* much of the same shape, tho' different in size from one another.

And I remember, having long since dissolv'd several Saline Bodies together in Water, by a gentle Evaporation, they have yielded Concretes, different in shape from each of the Ingredients; but it oftentimes is very difficult to associate them, because some are dispos'd to *Crystallize* sooner than others: As may be observ'd in purifying *Barbary Nitre*, from the common Salt it is mix'd with; and as *Agricola, lib. 12. de re Metallica*, takes Notice, where a *Vitriolate Substance*, and that from whence *Allom* is drawn, are joyn'd together; yet *Venetian Borax*, tho' *Crystals obtain'd from Venetian Borax.* made up of several Salts, yields *Crystals* of very Regular and Geometrical Figures: And the *Caput Mortuum* of common *Aqua fortis*, which consists of Bodies disagreeable in Nature, by frequent Solutions and Coagulations of their Saline Parts, yield Salts of very curious Figures, as Triangles, Rhomboids, Hexagons, Prisms, and Pyramids, compos'd of several Triangles, meeting in a Vertical Point, and as curiously shap'd as *Cornish Diamonds*.

F.

But

But the Acquisition of new Shapes, by being compounded, is not only practicable in these Groſſer, but even in *Chymical Salts*, which affect one another, with an *Ebullition*; becauſe in that Conflict, the Volatile Spirits unite and loſe much of their Force; ſo that being leſs apt to fly away upon Evaporation, they form curiouſly ſhap'd *Crystals*; as I have Experienc'd with Spirit of Urine and Spirit of Nitre, Spirit of Sheeps Blood and of Salt, Spirit of Nitre and Oyl of Vitriol, and likewiſe with Spirit of Salt and Spirit of Urine; the laſt of which ſhews, how much Compound Figures are owing to the Union of the Particles of the Ingredients, of which they are compos'd; the Spirit of Urine and Salt, affording *Concretes* different from thoſe of Oyl of Vitriol and Spirit of Urine; the ſhape of the firſt being like that of a Comb, whoſe Teeth ſtand out on each ſide; or like a Feather, the *Crystals* on each ſide being ſo much inclin'd: *Crystals* of a like Figure to which, ariſe from a juſt Proportion of Soot diſſolv'd, and coagulated with common *Sal Armoniack*.

Salts obtain'd from Spirit of Urine, and Nitre, &c.

From Soot and Sal Armoniack.

Fourthly, To confirm what I have above deliver'd concerning the Origin of *Vitriol*; and alſo to make it appear, That the Figure of its Parts depends on the Texture of its Ingredients, I ſhall add another Particular, which is, That having compar'd the Composition of Artificial *Vitriol*, I thought it might reaſonably be rank'd under the ſame *Species* with the Natural: To which I ſhall ſubjoyn, that having alſo conſider'd, that Oyl of *Vitriol*, and Spirit of Salt, were improper *Menſtrums* to diſſolve ſeveral Metals, I made uſe of *Aqua fortis*, which with Copper, made a Curious
Vi-

Vitriol; and with *Silver*, it afforded *Crystals* shooting into thin *Plates*; and with *Lead* and *Quick Silver*, it yielded *Crystals* far more thick, and differently shap'd from each other.

Now if from hence it appears, That the Curious Figures of *Salts*, generally alledg'd as Arguments of the Necessity of *Substantial Forms*, depend meerly upon *Texture*; why may not the more Ordinary *Phænomena* of Nature, since it is manifest that *Matter*, and a *Congeries* of *Accidents*, are sufficient to account for what is usually attributed to *Imaginary Forms*? Neither can I see Reason, why Arguments grounded on the Qualities and Effects of *Bodies*, esteem'd factitious, may not be sufficient to shew us, what may be ascrib'd to the *Mechanical Affections* of the universal Mass of Matter; since it is not agreed how factitious shall be distinguish'd from that *Species* of Body, call'd *The Productions of Nature*. In favour of which *Gun-Powder* is no despicable Instance; where by a bare Mixture of *Nitre*, *Char-*^{The Ingre-}
coal, and *Sulphur*, without the least shadow for ^{dients of}
the Pretence of a *Substantial Form*, a Body is ^{Gun Pow-}
produc'd, of Effects more prodigious, than any ^{der.}
of Nature's Production: Nor can Nature produce a more Noble *Concrete* than *Glass*, which is but the Product of Matter, brought together by *Art*; where in less than an Hour, an *Opaque Body* becomes transparent, and acquires several other Qualities, for as much as appears to Sense, without the Addition of any other Body; which yet by another change, in a trice, may make a Substance not *Glassy*, but *Opacons*.

* Substantial Forms not necessary to Discriminate Bodies.

* Nay, the *Aristotelians* themselves allow, That there may be slight Changes in Matter, so as to

distinguish *Genus's*, without an Introduction of *Substantial Forms*; as in *Coral*, which in the bottom of the Sea is tender, and grows like a Plant, yet when harden'd in the Air, it is by several Eminent Writers, class'd amongst Stones: And indeed, its *Calx* is very much unlike the Ashes of Plants, being apt to be corroded by *Vinegar*, as *Lapis Stellaris*, and several other Mineral Stones are.

And a thing equally to be admir'd, is to be seen in *Sombrero*, an Island in the *East-Indies*, near *Sumatra*, according to Sir *James Lancaster*; who relates a Story of a *Worm*, which is transform'd into a *Tree*; and that again into a *Stone*, much like white *Coral*: And *Piso*, in his History of *Brasil*, vouches many Witnesses for the Transformation of Animals like *Grass-hoppers*, into *Vegetables*. Likewise *Michael Boym*, a *Jesuit*, affirms, That he saw in the Island *Hainan*, in *China*, *Crabs*, which pull'd as out of the Water, were immediately petrify'd.

Oyl of Vi-
triol turn'd
into Allom.

Sales ob-
tain'd from
Spirit of
Nitre and
Pot. Ashes.

But, *Pyrophilus*, that I may draw to a Conclusion, I shall only further add, to what hath gone before, that Remarkable Experiment of *Hellmont's*, which is that Oyl of *Vitriol* may be turn'd into *Allom*, by the Fumes of *Mercury*: To which may be added another Instance, presented us in the Production of *Salt-Petre*: For if on the white *Salt*, afforded by Solution of *Pot-Ashes*, Spirit of *Nitre* be pour'd, till they cease to ferment, that Mixture will yield *Crystals* endued both with the Shape, and other Qualities of *Nitre*.

CHAP. VII.

Experimental Attempts concerning the Redintegration of Bodies.

HAVING already to confirm the Origin of *Forms*, as intimated in our Hypothesis, alledged the Measures taken in the Productions of *Forms*, I now proceed to illustrate it from their Reproduction, which might prove the stronger Argument of the Two, could it be clearly made out; because to Re-produce a *Body*, whose Substantial *Form* hath been destroyed, may argue, that a *Form* is only a Modification of the Parts of Matter of which a *Body* is composed, in such order in reference to each other, as is requisite to produce such Properties: Whereas were those Parts otherwise placed, they would make up a *Body* of a different Nature; which would be again of the nature of the former were the Parts of which it consists associated in their former Order.

But tho' an Adæquate *Redintegration* of *Bodies* Chymically Analyzed were impossible, by Reason of some Dissipated Parts; yet such a one as is possible, may be sufficient to our Purpose; which is the Experiment concerning the *Reproduction* of *Salt-Petre*. But Experimental Attempts of this kind being very difficult, all that I shall do at the present, is, to represent that Difficulty. And

*An At-
tempt to
re-unite the
Parts of
Amber.*

First, we shall do it by relating our Success in an Attempt to dissipate and re-unite the Parts of common *Amber*; for having put Four or Five Ounces of *Amber* into a Glass *Retort*, by a gentle Heat it began gradually to melt and bubble; and after the Operation was ended, we found in the Receivers half the weight of the *Amber*, consisting of a Mixture of Volatile Salt, Spirit, Phlegm and Oyl; and in the bottom of the broken Retort, we found a Cake of Matter very black, yet so smooth, that nothing could be finer Polished; so that it might very well have supplied the place of a Looking-Glass; which, when it was broke, the Fragments were accompanied with a more than ordinary Lustre. All which divided Parts of *Amber* being mixed in a Glass Body, to which a Blind Head was luted, and placed in Sand, the Fire being by Accident increased, the Fumes raised the Vessel out of the Sand, which falling, the Top of it was broke, by striking against the side of the Furnace, and the Fumes flew away. The remaining Matter was very like *Tarre*, but would not Tincture Spirit of *Wine*; tho' with Oyl of *Turpentine*, it would make a Blood-Red Balsom. The whole Process being again renewed, and some Accidents happening, we could not finish the Experiment.

*An At-
tempt to
re-unite the
Parts of
Roch-Al-
lom.*

But notwithstanding the Difficulty of Tryals of this kind, having once drawn what Quantity I could of Phlegm and Spirit from *Roch Al-
lom*, and poured it again upon the *Caput Mor-
tuum*, after some time, some Parts were so associated again, as to form several curiously figur'd Crystals:

Cryſtals : And though *Vitriol* may ſeem a Body unapt for ſuch Experiments, yet I once drew from blew *Vitriol* a Phlegm and Spirit together, with a heavy Oyl, which being divided into ſeveral Parts, the red *Caput Mortuum* was divided into an equal Number, one part of each of which being mixed over Night, in the Morning I found ſeveral Grains of pure *Vitriol* upon the Surface of the Matter ; which I again found upon the Mixture of another part of the Powder and Liquor, only more in Quantity ; and this Experiment was alſo confirm'd by a Third Tryal.

An Attempt to re-unite the Parts of Vitriol.

To theſe I ſhall add, what happened upon the digeſſion of powdered *Antimony*, with a double quantity of Oyl of *Vitriol* : For having drawn from it a little Liquor, together with a conſiderable Quantity of combuſtible *Antimonial* or *Antimonio-Vitriolate Sulphur*, the *Caput Mortuum* remaining in the Retort was light and friable, and upon the upper part white like common Wood-Aſhes ; the reſt being like a Cinder. Whereupon we expoſed it to the Fire, in a Retort of Glaſs well Coated, and fitted with a Receiver ; and after ſome time ſeparating the Veſſels, we found very little *Sulphur* ſublimed ; and not the leaſt *Antimonial Quickſilver*, but the *Caput Mortuum* was united into a Maſs of black *Antimony*, covered over with white transparent Glaſs. From whence we may infer, that *Antimony* generally abounds with more *Sulphur* than is requiſite to conſtitute that Mineral ; though in this Experiment we might ſuſpect, that part of it was turned

As alſo of Antimony and Oyl of Vitriol.

into Glass, by the Loss of the Sublimed Sulphur.

Another to re-unite the Parts of Vitriol.

But amongst all my Experiments of the Reintegration of Bodies, the following was the most successful; for having distilled from several Ounces of Turpentine in a Glass Retort, a considerable Quantity of Transparent Liquor, and a dry brittle *Caput Mortuum*, I reduced the *Caput Mortuum* into Powder, which by that means was turned from a Red, to a pure Yellow Colour; and being mixed with the Liquor, was formed into a Red Balsam; which, by a continued Digestion, began to lose that Colour, so that the Powder being wholly dissolved, it could not be distinguished from Laudable Turpentine.

CH A P. VIII.

Experiments concerning the Origin of Qualities and Forms.

HAVING in some of the foregoing Chapters, given a short Scheme of the Principles of the *Corpuscularian* Philosophy, for the better understanding our Experiments concerning the Productions and Changes of Particular Qualities, I shall now lay down such Natural Phenomena as induced me to take up such Notions, in which, not Art but Nature discovers her Operations.

EXPE.

EXPERIMENT I.

The First I shall begin with is, what occurs in hatching of an *Egg*. And

First, we are to consider, that in a Prolifick *Egg*, by the same Reason, that Bones and Membranes are called *Similar Parts* of an Animal; the Liquor of the Yolk, as well as the White, is to Sense, a *Similar Substance*, though by Distillation several Substances may be drawn from them.

An Experiment to illustrate what hath been delivered concerning Forms and Qualities.

Secondly, That by beating the White of an *Egg* well, it loses much of its Tenacity, and becomes a fluid Body; in which Agitation, there is only a Mechanical Alteration of the Texture of the Body.

Thirdly, That the Rudiments of the *Chick*, lodged in the *Cicatrix*, are nourished only by the *White*, till it becomes a great *Chick*; the *Yolk* being reserved as a stronger Nourishment, till the *White* is spent, and the *Chick* is able to digest it; and in effect the *Chick* seems to be furnish'd with Head, Wings, Beak and Claws, before the *Yolk* is touched.

Lastly, It is not a little to be admired that so Soft and Similar a Liquor as that of an *Egg*, should be in so short a time, changed into a *Chick*, endowed with Organical Parts of different Fabricks; and Similar ones different in Texture very much from one another; besides the Liquors contained in the Solid Parts, being as different as the former, and endowed

First,

First, With new Qualities, as Colour, Taste, Odours, Heat, Hardness, &c. *Secondly*, Qualities distinct from Sensible ones, as Fluidity, Consistency, Hardness and Flexibility, &c. *Thirdly*, Occult Qualities, as when Birds or Parts of Animals, afford Specifick Medicines, or at least most Noble ones. But

Fourthly, since some may Object, that these Parts are formed by the Plastick Power of the Soul, and that a *Chick* is not a Mechanically contrived Engine, we are to consider, that let the Plastick Principle be what it will, yet still, being a Physical Agent, it must act after a Physical manner; and having no other Matter to work upon, but the *White* of the *Egg*, it can work upon that Matter but as Physical Agents, and consequently can but divide the Matter into Minute Parts of several Sizes and Shapes, and by local Motion so variously contex them, as is requisite to produce an Animal of this or that Species; though from so many various Textures of the Parts formed, there must naturally arise such different Colours, Tastes and Consistencies, and other Qualities, as we have taken Notice of: For we are not here to consider so much, what is the Agent or Efficient in these Productions, but after what manner the Matter they are made of, is affected in producing them: To illustrate which, we may observe, that a Man who is to frame a Building, or some curious Engine, though he may by the help of Reason and Art, skillfully contrive his Materials, yet he can but move, divide, transpose and contex the several Parts, into which he reduces the Matter assigned.

And

And that the Soul of a *Hen*, does not any more contribute to the forming of a *Chick*, is plain; since we are assur'd, that multitudes of *Eggs* may be hatch'd meerly by the regulated Heat, either of Ovens, or Dunghills: Whence it easily appears, That the *Plastick* Power, no otherwise contributes to the Formation of a *Chick*, than by guiding the Parts of the White, put into Motion by the external Heat; so, that they may associate after a manner necessary to produce an Organical *Chick*.

EXPERIMENT II.

Water, tho' a Homogeneous, Diaphanous, Fluid Body, devoid of Colour, Taste and Smell, &c. may, by altering the Texture of its Parts, acquire Attributes different from these: This is evident, in the Growth of Vegetables, when nourish'd even by simple *Water*, in Bottles; where I have observ'd, that Crows-foot, after six Months Growth, weigh'd above three times as much as before it was put in. But not only Crows-foot, but several other Plants, owe their Substance to the Particles of *Water*, alter'd in Texture, as *Spear-mint*, *Marjorane*, *Raphanus Aquaticus*, and *Ranunculus*: From whence we may infer, that the same Particles of Matter which compose *Water*, may, by having their Parts differently modify'd, produce several *Concretes*, endu'd with different Qualities, as Firmness, Volatility, Colours, Smell, and Taste; together with other Specifick or Occult Qualities: Yet it is to be admir'd, that so insipid a Body as *Water*, should be converted into a Juice so caustick, as that of *Ranunculus*, or

Water may, by altering its Texture, put on New Forms.

one

one so inflammable as Oyl, which may be drawn by Distillation from Plants, only nourish'd in Bottles.

OBSERVATION III.

*All Plants
may be nourish'd by one
and the
same Sub-
stance.*

It is usually believ'd, That Plants by the Faculties of a Vegetative Soul, select and suck in a Juice, appropriated to each; rather than that they are all nourish'd by one Juice differently modify'd in that Plant: But the Latter will easily appear, if we consider, what happens in Grafting and Inoculations; for if a Pear-Tree be Grafted into a White-Thorn, the Aliment suck'd in by that Root, will be so alter'd, as to yield Nourishment to a Pear; Fruit much different from that of the White-Thorn: The same is evident in Inoculations, where the Sap, selected by the Root, is so alter'd in the Bud inoculated; that the same Sap, which in the Genuine Branches of the Tree, constitutes one sort of Fruit, is turn'd into another, in those springing from the inoculated Bud. And here it is further Remarkable, That not only the same Juice yields various sorts of Substances in different Plants, but even in the same Tree; where the Skin of the Fruit differs from its Flesh, and *that* from the Stone, and all of them from the Substance of the Tree; not only in Colour, but several other Qualities; as the Blossoms of a Peach, have a Purgative Virtue, which is not in the Fruit: And *Garcias ab Horto* affirms, That the Seeds of solutive *Cassia fistula*, are Astringent: An Account not unlike to which we have of certain Kernels of a Fruit, much like a White Pear-Plum, by Mr.

Mr. *Lygon*, in his History of *Barbados*, p. 67, 68. Five of which work'd a dozen times upwards with him, and twenty times by Stool; yet by taking away a thin Film, which divides the Kernel into halves, the Nut is as sweet as a *Jordan* Almond, and has no sensible Operation: Which Relation is also favour'd by *Monardes*, under the Title of *Faba Purgatrices*, where he speaks of a Purgative Fruit, brought from *America*, from *Carthagena*, and also from *Nombre de Dios*. And *Vinsent le Blank*, in his Survey of the World, p. 260. Part. 2. gives an Account of a Golden Apple, as bitter as Gall, containing Five Kernels, of an equal Bigness with Almonds, whose Juice is sweet; and he also relates, That of a thick Film, which encompasses the Nut in the Shell, they prepare an Excellent Sweet-Meat.

OBSERVATION IV.

We have also an Instance, how Matter may be alter'd, by a Variation of its Texture in Rotten ^{Further Instances in} Cheese; which differs from the Sound, both in ^{Cheese.} Colour, Taste, Smell, and Consistence. In which likewise, by a good *Microscope*, we may perceive Clusters of Animals, endu'd with Parts very differently modify'd, and Qualities little different from Occult ones.

CHAP.

CHAP. IX.

*A Continuation of Experiments concerning
Forms and Qualities.*

EXPERIMENT I.

MIX a convenient Quantity of *Camphire*, grossly beaten, with Oyl of *Vitriol*, and when it begins to dissolve, and, by shaking the Glafs, to mix with the Oyl, it will first tinge it with a Yellow, and afterwards a Colour not much different from Red; which Tincture will be so deep, as to render the Clear Oyl Opacous. And from the Ingredients perfectly mix'd, if in just Proportion, may be obtain'd a Liquor void of a *Camphire* Smell; yet by the sole Addition of Fair Water, the Mixture will become Pale, and the *Camphire* will again associate, and form a floating Combustible Body as before dissolv'd, and renew its Odour.

Several
Phenome-
na the Re-
sult of a
Change in
Texture.

From the *Phænomena* of this Experiment, may be drawn several Instances to our Purpose.

I. That a Light Body reduc'd into Parts, conveniently Figur'd, may be mix'd with a Body heavier than it self; so that *Gold*, the heaviest of Bodies, may float in a Liquor, if its Parts be dissolv'd, and render'd minute enough by *Aqua Regis*. From which two Observations we may Learn; That the Textures of Bodies, as well as the Rules of *Hydrostaticks*, are concern'd in determining, whether Bodies will sink or swim.

II. That

II. That several Colours may be produc'd, by a Mixture of a Colourless Liquor, and a White Concrete.

III. That those Colours may again be destroy'd, and the former renew'd by *Water*, which can neither afford the Colour it reduces *Camphire* to, nor destroy that of the Liquor.

IV. That a Light Body emerges out of one much lighter, which did not in a heavier Liquor, which the Mixture was before the Addition of *Water*; which may be an Argument against the Schools concerning *Mistion*; since some of them assert, That, in *Mistion*, the Elements depose their own Forms, and put on new; whereas the *Camphire* had not its Form destroy'd throughout the Process; but still retain'd its own Qualities in a Disposition to be again united.

V. It is to be admir'd, That Odours should depend on so slight a Texture, that *Camphire*, by a bare Separation of its Parts, should lose its Scent, and upon the Mixture of a Body void of Odour, should again recover its Smell; and that so slight a Texture, as that of the *Oyl* and *Camphire*, should, as to Sense, wholly for a time alter the Qualities of the Latter: And that several of the preceding *Phanomena*, are caus'd by the Particular Texture of the Liquors, made use of to exhibit them, is manifest, because if *Camphire* be cast into Spirit of *Nitre*, well dephlegm'd, it will not afford those *Phanomena*, which it does with *Oyl* of *Vitriol*. And when to the Red Mixture, above-mention'd, two or three parts of Spirit of *Wine*, were added instead of *Water*, no such Changes succeeded; but the whole Mixture, with its Accidental Colour, was dissolv'd by it, being
in

in Colour much like Red *Turbid Wine*: So that the Colour of the Mixture was wholly owing to the Mixture of the *Oyl* and *Camphire*, and depended on their Union; which is further confirm'd, because when we added a sufficient quantity of *Water* to that Turbid Liquor, it presently depos'd its Colour; and the Particles of *Camphire* immediately emerged in the Form of a white Powder.

But there are other *Phænomena*, which by a prosecution of this *Experiment*, the Mixture afforded us: For,

VI. Having kept the Mixture moderately warm in a Glass Retort, and distill'd it; the Liquor drawn off had a Smell, unlike both that of the *Camphire*, and also that of the Mixture: And the Ingredients united in this Mixture, were both Transparent, in the Sense that Fluid and Solid Bodies contus'd are said to be so; yet the Remaining Mass, not only became *Opacous*, but of a very Black Colour: some Parts of it, being not unlike polish'd *Jets*; which is the more Remarkable, because *Camphire* *Chimically* handled, usually ascends in White Flowers, leaving behind them a *Caput Mortuum* of an Agreeable Colour.

VII. The last *Phænomenon* this Mixture afforded us was, That tho' *Camphire* be a Body very much dispos'd to dissipate, and fly away; yet by the Association of the *Oyl*, it might be kept together, so that the *Caput Mortuum* above-nam'd, was able to endure a pretty hot Fire in the Retort, before it was reduc'd to that Pitchy Substance, lately taken Notice of: And further it was Remarkable, That Part of the Substance being taken out of the Retort, and kept in a Red-hot Crucible
for

for half an Hour, it afforded a considerable quantity of Black Brittle Matter; without the least Smell of Camphire: *Fixedness and Volatility* are so much vary'd by *Texture*.

EXPERIMENT II.

Amongst the various *Experiments*, which might be produc'd to prove, That the *Diversity* of *Qualities* depends on the various Alterations of *Texture*; I shall instance those afforded me in Copper and Silver; by the Intervention of Sublimate; where we shall have a Considerable Number of Changes, made by the Recess, Addition, and Trasposition of the Insensible Parts of Matter.

Diversities of Qualities depend on Variety of Textures.

First then, Having put a Pound of *Venetian Sublimate*, grossly beaten, into a Glass Retort; we threw in Copper Plates, an Inch broad, and about as thick as a Grain of Wheat; so that the Ascending Fumes, might by Compulsion act on the incumbent Metal: Which being done, we plac'd the Retort in a Sand Furnace; and having adapted a small Receiver, we continu'd a Gradual Fire, for seven or eight Hours; and at the last increas'd it to a considerable degree, which was as high, as the Furnace would permit: The Effects of which Operation were the following.

1. Very little Liquor was carry'd over into the Receiver, but about ten Ounces of Sublimate was crufted over the Neck of the Retort: The Retort contain'd two Ounces and a Quarter of Running Mercury; and what was to be admir'd was, the Acid Spirit, uniting with the Copper; left the Mercury unaffected.

F

2. When

2. When the Fire was increas'd, the Matter, beginning to Melt in the Retort, made a Noise not unlike to *Mercurius*, when brought to a Fusion, in a Calcining Pot: which Circumstance constantly accompany'd this Experiment; whereas the same Experiment being again try'd, we scarce could find either in the Retort, or Receiver, the least Running *Mercury*.

3. The Lump of Metal in the Retort, was heavier by more than two Ounces; some of the Plates being too thick, and yet retaining their Shape and Malleableness; the others, being changed into a Brittle Lump, like a piece of good *Benjamin*, which, when broke, was of divers Colours, and almost Transparent.

4. But this Lump, being divided into smaller Pieces, and expos'd to the Air in white Paper, in a Night's Time it was Colour'd like *Verdigrease* on the out-side; which by its longer continuance in the Air, penetrated deeper; yet the Paper which it stain'd, was ting'd with a Green, inclining to Yellow. And here we may take Notice of the strange Subtlety of the Air, which alter'd some of these Fragments so, that they were cover'd over with a Powder, like *Verdigrease*, notwithstanding they were shut up in a close Box.

5. Here I shall observe, That several Copper Plates, off which Sulphur had been drawn, had not their Shapes alter'd in the least; but were colour'd over with a white Silver colour, which penetrated the whole Substance of them, being much more glorious within, than on the Surface of the Metal: so that we suspected the Sublimate to be adulterated with *Arsenick*; but that it retain'd

tain'd its Malleableness; which *Arsenick* usually takes away.

6. We thought it more considerable, because the *Venus* of the Copper was so unlock'd, that the fore-mention'd Transparent Substance, would melt like Rosin, and burn with a lasting Flame, if laid on a Red-burning Coal, or held to a Candle, much like the Flame of *Sulphur*, only more Green.

To these *Phænomena*, afforded by Sublimate and Copper, I shall joyn some, observ'd in the like Experiment, with Sublimate and Silver.

We put ten thin Silver Plates into a well-coated Retort, with double the weight of Sublimate upon it, which when Sublim'd, the Sublimate ascended into the Neck of the Retort; in which was to be found several Portions of Reviv'd *Mercury*: In the bottom of the Retort was a Lump of Matter, which could scarce be separated from the Glass, but was brittle and of a Pale Yellow, and much of the same weight with the Metal. In the middle of the Lump, were contain'd pieces of Silver very brittle, but not totally dissolv'd: This Rosin, as that of Copper, when moisten'd by the Air, was in 24 Hours cover'd over with a Greenish Dust; but whether it were the Result of Sublimate working on the Copper, which Silver is generally alloy'd with, or on the Compound Metal, I will not dare to determine: Yet it is usual for *Painters* to make a fine kind of Azure of Silver, by corroding it with Saline Bodies: All that I shall add to be observ'd in this our First Tryal, is that this Rosin, when cast upon hot Coals, continu'd flaming for a considerable Time, the Colour of the Flame being very like that of Copper.

But for a Second *Experiment*, we made use of an Ounce of Refin'd Silver Laminated, and cast upon double its quantity of Sublimate; which, by the violent Force of the Fire, being partly melted, we found in the Retort a Lump of Matter, which in some places next the Glass, was cover'd with a thin Plate of Silver, the remaining part of the Metal, (except some small pieces) being dissolv'd into a Substance, neither like Silver, nor any other Metal or Mineral. In which process it is strange, that so fix'd a Metal, should, by an Addition of a Fourth Part of Matter, be so alter'd in its Qualities; as also, that a Mass of an Amber or deep *Amethystine* Colour, (some of whose Parts on the upper Superficies were of a light Yellow, which on the lower ended abruptly in a colour not far from a Black one) should be the Result of a Mixture of two white Bodies: Nor is it less to be admir'd, that a Body Transparent like Amber, should be made of so Opacous a Body as Silver, mix'd with a white Powder; and that Silver, instead of the Qualities of a Metal, should become a Friable Body; and when cut with a sharp Instrument, like Horn; as also, that it should be chang'd into a Body, apt to take Flame at a Candle, which before was difficult to melt.

These *Experiments* being try'd; To shew how much these Qualities depended on the Particular Textures of Bodies, I took two distinct Urinals, and put Gold finely Laminated in one, and Refin'd Gold in the other, with a treble weight of Sublimate to each; which tho' rais'd in a Sand-Furnace, alter'd neither of them: But in these *Experiments*, being forc'd to make use of a Sand-Furnace, I could not employ a Fire so strong as

I could have wish'd for, which might in some measure alter the *Phænomena*, which our *Experiment* might have otherwise afforded: But,

Before I leave this *Experiment*, it may not be improper to give the following Advertisement, *viz.* That a further Improvement might be made of this *Experiment*, by making use of several kinds of Sublimates; which might easily be obtain'd by raising several other Bodies up with Sublimate. Of which I shall add an Instance; for having Sublim'd a Mixture of equal Parts of Sal Armoniack, and Common Sublimate, in Urinals plac'd in a Sand-Furnace, I obtain'd a Sublimate different from the former; for Salt of Tartar dissolv'd, being drop'd into the Common sort dissolv'd in Water, turn'd it into an Orangetawny Colour, but chang'd a Solution of the other into a Liquor white like Milk.

To try the Effects of this New Sublimate, we Sublim'd it with a Mixture of Copper in the Retort, in the bottom of which was to be found a Cupreous Rosin, which would, as the other above-mention'd, turn to *Verdigreese*: But it is very Remarkable in this *Experiment*, That the Sublimate was ting'd with a Blewish-Green, by Particles of the Copper carry'd along with it; and also, that in the Receiver, was found near an Ounce of Liquor ting'd with Copper: From whence it appears, That this open'd the Texture of Copper, more Powerfully than the other Preparation of Sublimate.

The same
Method is
not requisite
to produce a
Body, pro-
vided the
Result be of
the like
Texture.
* The Pre-
paration of
Luna Cor-
nea.

EXPERIMENT III.

To make it appear, That there are several Ways to produce the same Qualities in Bodies, provided the change of Texture be the same, I shall instance a Particular Experiment made with what the *Alkymists* call * *Luna Cornea*.

Having dissolv'd Refin'd Silver in *Aqua fortis*, and Filtrated the Solution, we dropt Spirit of Salt into it, till the Liquor would no longer curdle, which being Filtrated through Cap-Paper, we dry'd the Remaining Substance, wash'd and clear'd from its Salts, whilst it remain'd in the Filtre, by running fair Water through it; when dry'd, it was melted into a Mass in a Viol, cover'd with Ashes, and being preserv'd in Fusion for a little time, afforded a *Luna Cornea*. But if instead of dropping the Salt upon the Solution, the same Method just before laid down, be taken with the *Crystals* yielded by that Solution moderately evaporated, they will shoot into *Diaphanous* brittle *Crystals*, much different from those of other Metals endu'd with several other Qualities, the Quantity of Salts interpos'd betwixt the Parts of the Metal weighing but a third part of the Compounded Mass.

In the Foregoing Process, the following *Phaenomena* may be taken Notice of, to our present Purpose:

First, That tho' Acids, and *Alcalyes* have generally contrary Effects, yet both Oyl of Tartar per Deliquium, and Spirit of Salt have the same Effect in Precipitating Silver; which evinces, That the Precipitation of Bodies is neither to be attributed to *Alkalies* nor Acids, consider'd as such;

such ; But to a mutual Interposition and Texture of the Parts of the Matter, whereof those Bodies consist.

Secondly, It may be observ'd, That Bodies *Diaphanous*, and void of Colour, may be chang'd into *Opacous*, and white ones.

Thirdly, That a white Powder may be turn'd into a Yellow Body, in some measure Transparent.

Fourthly, That Silver by a Mixture of Saline Parts, may be render'd so apt to Fusion, that it will melt like Wax at the Flame of a Candle.

Fifthly, It is remarkable, That tho' either of the Ingredients of this Mix'd Body, would readily dissolve in Water ; yet the Composition would not.

Sixthly, It is to be admir'd, that a Body in Texture, not unlike a piece of Horn, should be the Result of an Association of two rigid Bodies : Wherefore to be satisfy'd, That the Alteration depended on the Texture of Parts of the Ingredients, I made use of the Oyl of *Vitriol*, instead of Spirit of Salt, and found that the *Concrete* resulting from an Union of that with the *Crystals* of Silver, differ'd from the former, it being much more brittle, and easily divided into Parts.

But what is more remarkable is, That a Body compounded of one of the most Bitter, and another of the sowerest Taste, should be it self insipid, or of a different Taste from either of them : And it is yet as strange, that Salts so fugitive, and apt to dissipate in the Air, as those of *Aqua fortis* and Spirit of Salt, should by acquiring a New Texture put on such a degree of Fixedness, as to melt with a Metal, and that without the least perceivable Evaporation.

E X P E R I M E N T IV.

Several
Phenome-
na in Proof
of the De-
clin of
Forms and
Qualities.

Having made a Salt of very different Quali-
ties from all others, and which is so nice in the
Preparation, that it is as difficult to direct how
it is to be made, as to make it; I shall rather
chuse to mention what *Phænomena* it afforded
me.

The First Thing Observable was, That tho'
the Ingredients of this Salt were Eminently Sa-
line, yet the Salt it self was judg'd by a Stranger
to be Sweet, tho' it had a Sweetness peculiar to
it self, as every Sweet Body hath: Another Thing
Considerable is, That tho' it be of an Inoffensive
Smell, when cool; yet if expos'd to a considerable
Heat, it emitted *Effluviūms* more strongly said
than those of *Aqua fortis*, Spirit of *Armoniack*
Salt, or Distill'd Urine; whereas those Fumes
being again united, into a Salt, became Inoffen-
sive as before.

And it is further to be Observ'd, That tho' all
Volatile, Fix'd, and Lixivate Salts are so speci-
fically different from each other, that being mix'd
together, they ferment, and by that means destroy
each other, and unite into a Substance different
from each; yet this Salt is so powerful, as to be
destroy'd by none of them; but being mix'd with
any of them, remains quiet, and without the least
Ebullition; But to be further satisfy'd that it
was different from each of the foremention'd
Salts; I try'd several Experiments, by which I
found, that it would neither turn Syrup of Vio-
lets red, as Acids do, nor green, as Volatile and
Fix'd Salts usually do; and tho' Spirit of *Armo-*
niack,

niack Salt, or Urine will turn a Solution of Sublimate in Water, white; and Salt of Tartar will give it an Orange Colour; yet was it not in the least alter'd by this: Nay, tho' this Salt was dropt into a Solution of Syrup of Violets, along with Acids and *Alkalyes*, yet did it not hinder their Effects: Tho' in Dissolving several Substances, this Salt exceeds both *Aqua fortis*, and Oyl of Vitriol.

And it is further Observable, That tho' by a gentle Heat, this Salt wholly Sublimes; yet when mix'd with Liquors, it does not fly away, as other Volatile Salts do; and tho' it be Volatile, yet it will run *per Deliquium*, as soon as any Salt can do, and as present reassumes its own Form, the Superfluous Moisture being taken from it; add to this, That by a gentle Heat it may be dissolv'd in a Limpid Liquor. And, it is endu'd with a Quality yet more Admirable, for it will readily dissolve, either in Spirit of Wine, or Water, or Oyls themselves: whereas some Bodies which may be dissolv'd in Water, cannot incorporate with Oyls or Spirit of Wine, and *è converso*.

EXPERIMENT V.

The *Experiment* which I am about to deliver, I presume, will be sufficient to shew, That Considerable Alterations in Bodies may be effected, by the Access of some Parts, and a Recess of others, the Remaining Parts being Modify'd afresh. The *Experiment* is the following, *viz.* Digest for some Time one Part of Sea-Salt, with a double Proportion of Spirit of Nitre; which being

Several Changes in Bodies may be effected by the Addition, or Subtraction, and new Modification of Matter.

being distill'd in a Retort, till the *Caput Mortuum* remains dry, the following Changes of Qualities will be observable; First, That it becomes an *Aqua Regia*, and would dissolve Gold, but not Silver; yet would precipitate the Latter when dissolv'd in *Aqua Regia*: Secondly, The Taste is more mild, affecting the Sensory, rather like *Nitre*, than common Salt: Thirdly, It becomes Fusible, like *Salt-Petre*; and like *Nitre*, dissolves in the Flame of a Candle.

An Acid
may be
turn'd into
an Alkaly.

But Fourthly, Tho' it be a Quality of *Sea-Salt* to resist the Action of Fire, and of Acid Spirits to cool Inflammations; yet a Lump of this Matter cast upon Coals, flam'd like *Nitre*; as also by an Addition of Charcoal, when melted in a Crucible, it wou'd burn with a lasting and splendid Flame, which would again renew, upon a fresh Addition of burning Charcoal. But what I chiefly design'd in this Experiment was to turn an *Acid* into an *Alkaly*, which was effected by consuming the more Fugitive Parth of the Salts, by repeated Deflagrations; whereupon it acquir'd, instead of an *Acid*, a Lixivate Taste; would turn Syrup of Violets green, precipitate a Solution of Sublimate, into an Orange Colour; and as other fix'd Salts, would ferment with even Spirit of Salt; which *Alkalyzate* Nature, could not be suppos'd to proceed from the Charcoal Ashes; because the whole Quantity made use of, could not yield above 2 or 3 Grains of Salt: Yet that I might be further satisfy'd, I drop'd a sufficient Quantity of *Aqua fortis* upon the Lixivate Salt, till the Mixture ceas'd to ferment; which upon Coagulation, shot into *Saline Crystals*, from the Inflammable Qualities of which it

it appear'd, That the *Nitrous* Spirit was united with the *Alkaly*. And if it should be again suspected, that the *Alkaline* Parts were only the Remains of some of the *Aqua fortis*, which might be carry'd over into the Receiver: I answer, That *Nitre* being an Acid, it must follow that two Acids united, were turn'd into an *Alkaly*.

And to prosecute this *Experiment* further, we distill'd a Mixture of Spirit of *Nitre*, with a double Proportion of Spirit of *Salt*; yet tho' some Parts of the *Nitre* were carry'd over with the *Salt*, the Remaining Substance would wholly flash away, if plac'd upon the Coals, like common *Nitre*.

EXPERIMENT VI.

Having Distill'd Oyl of *Vitriol* with a Solution of *Nitre* in a Glass Body and Head plac'd in Sand, I drew from it a *Spiritus Nitri*, which before Rectification would dissolve *Silver*, tho' it was diluted with Water treble to the weight of the *Nitrous* Parts. And from the Matter left behind, and evaporated to a Driness, I obtain'd a Salt, which would shoot into *Crytals*, neither like those of Crude nor fixt *Nitre*, nor those of *Vitriol*, but of a Figure hard to be describ'd. As for the other Qualities of it, it was easily fusible by Heat, yet was not inflammable like *Nitre*, tho' quick Coals were thrown upon it in a Crucible; for it was so far from that, that when it was hot enough to kindle *Sulphur*, it neither flash'd nor flam'd it self, as *Salt-Petre* usually does; yet this white Substance, being kept in Fusion for a while, with a little piece of Charcoal in it, smell'd very strong

Several
Phenome-
na exhibi-
ted by a
Mixture of
Oyl of Vi-
triol, &c.

strong of *Sulphur*, and had a very Fiery Taste on the Tongue, as also a Colour very red.

Encourag'd by these Circumstances, (they being agreeable to what *Glauber* relates of his Salt) and since he made use of Vessels of Silver, I judg'd it could not be *Aqua fortis* that he open'd the *Sea-Salt* with; nor common Spirit of Salt, because too weak; wherefore having put an equal weight of Oyl of *Vitriol*, and *Sea-Salt* together, into a Glass Cucurbite set in Sand, I obtain'd, besides Phlegm, a Spirit of Salt; which mix'd with Spirit of *Nitre*, dissolv'd Crude Gold; and likewise when pour'd upon Spirit of Urine, and fermented, till there no longer succeeded an Ebullition, after a gentle Evaporation, it shot into Crystals, like Combs and Feathers; from whence it appear'd to be of a like Nature to *Salt Armoniack*. The Experiment sometimes also succeeded, when instead of Oyl of *Vitriol*, I made use of Oyl of *Sulphur* by the Bell.

But to apply this Experiment to our present Purpose; we may observe, That tho' *Sea-Salt* be so fixt, as not to be rais'd without a considerable quantity of beaten Bricks, to prevent its Fusion, and a naked Fire; yet when its Parts are unlock'd by an Addition of Oyl of *Vitriol*, they may be carry'd over with a Moderate Fire in Sand, the *Vitriol* being fix'd and left behind; yet in other respects considerably chang'd, so as to be void both of the Taste of *Sea-Salt* and *Vitriol*.

And from this Experiment, what I formerly intimated, likewise appears; viz. That the Figures of Salts, by being embody'd with other Substances, might be so far chang'd, as to shoot into Crystals
of

of very different Shapes: For from the *Caput Mortuum* Dissolv'd, Filtrated, and leisurely Coagulated, may be obtain'd *Crystals*, much more transparent and of a different Figure from those of Sea-Salt, and from each other.

But to conclude this *Experiment*, I have found this Preparation of *Sal Mirabilis* very uncertain and tiresome, by reason of the Disparities of Bodies taken to be Oyl of *Vitriol*.

EXPERIMENT. VII.

To shew that all Metals and their different Qualities, were but the Effects of one common Mass of Matter differently Modified, as to the Shape, Size and Texture of their Parts; I took the following Method, viz. Having præcipitated the *Bezoardicum Minerale*, by an Affusion of Spirit of Nitre, on the rectified Oyl of Butter of Antimony, I drew off by Distillation as much of the Liquor as I could; sometimes cohobating it upon the Powder of the Antimony; which being done, I melted pure Gold with Three or Four times it's weight of Copper, which being put into *Aqua fortis*, the Copper was dissolved, and the Gold subsided in the form of a Powder, which was further purified by an Antient Chymist, and by a competent heat restored to it's Natural Colour; which being dissolved in a large Quantity of the above mentioned Liquor there remained a considerable Quantity of white Powder, which would neither be dissolved by the above nam'd *Menstruum*, nor *Aqua Regis*.

The different Qualities of all Bodies are the products of Matter variously Modified.

The

The Gold being a second time reduced to a Body, by a repeated Solution in the aforesaid *Menstruum*, yielded more of that Powder, which reduced to a Body was White, and being dissolved in *Aqua Fortis* had the same nauseous bitter Taste with Silver; so that it is plain the Transmutation of Metals is not impossible, nor Gold a Metal impossible to be destroy'd; so that I am more apt to believe, that by proper *Menstruums* the Body of Gold may be so ordered, as to communicate a Tincture to a Liquor duly conjoyned; as when Sulphur and Mercury by a Coalition constitute *Vermilion*; since from this Instance it is plain, that the Colour of the Tincture (as well as of the *Vermilion*) may be produced by the Position and Texture of some Particles of Gold associated with that Liquor.

The Trans-
mutation of
Metals not
impossible.

And that the Colour of such Tinctures as well as of the Gold it self depend on certain Particles conveniently Modified, I rather believe, because I am told, that a known Man in the *Netherlands* had a certain *Menstruum*, which would extract a blue Tincture from the Calx of Copper, prepared by a Dissolution in *Aqua Fortis*, leaving a white Powder behind, which would by Fusion be turn'd into a Metal of the same Colour.

A second Inference which may be drawn from the foregoing *Experiment*, is, that if Gold, one of the most Permanent Bodies, may have it's Texture destroyed, there is no Body in Nature but may undergo a Change, when wrought on by an appropriated Agent; and that

that the noblest of Metals may be Mechanically transmuted; from whence it appears also, that the noblest of Forms, are but the Results of the Texture of the Parts of Matter of which they consist; and a Convention of Accidents, which are the Substratum of that Texture: So that without a substantial Form, merely by a saline *Menstruum*, the Body of Gold may be changed into another substance, of very differing Qualities from what it had before.

But to render our present *Experiment* more instructive; I shall add another Attempt, to sublime Gold after the following Method. Having then dissolved laminated Gold in some of the above mentioned *Menstruum*, we drew it off in a Retort placed in a Sand-Furnace, by which means a considerable Quantity of Gold was elevated, and either fell into the Receiver in the Form of a Golden coloured Liquor, or shot into red Crystals like Rubies in the Neck of the Retort; which in the Air would run *per Deliquium*: Where we are to observe, that by a new Affusion of the *Menstruum* upon the remaining Calx, more of it would still be elevated by Distillation.

But to make this *Experiment* more serviceable, it will be necessary to Note, that upon pouring running Mercury into this elevated Tincture, the Particles of it were immediately Gilded, and by degrees, the Mercury being kept in Motion, the whole Liquor lost it's Tincture, which being decanted, and the Gilded Mercury with a good Quantity of *Borax* Melted in a Crucible, the elevated Gold was reduced into a Mass; which

which evinces what I just now taught, viz. that a Liquor might be Tinctured by having the Parts of that Body, from whence it received it's Tincture, conveniently interwoven in it's Texture, without being wholly destroyed.

And here I think it seasonable to advertise, that having elsewhere mentioned a Volatile Gold in some Oars, where none of that Metal is to be found; I would be understood to mean it Volatile in no other Sense, than the foregoing Sublimation intimates, viz. that it's Volatility depends on a mixture of Volatile Parts which carry it along with them, when dissolved into very minute Parts; so as to be capable of Swimming in that Vehicle.

EXPERIMENT. VIII.

*How so hard
a Body as
Silver, &c.
may become
a sower
substance by
an alteration
of Texture.*

Having dissolved an Ounce of refined Silver in *Aqua Fortis*, and permitted it to Crytallize, we found, that the Silver, by the addition of Acid Salts, was increased in weight several Drachms; which distilled in a Retort, with such a degree of heat as made the Retort red hot, yielded a Phlegm eminently Sower. Which shews, that a very Bitter Body may yield a substance of a quite different Taste. For the Liquor being cold in the Receiver, Smoaked as well as Smelt and Tasted like *Aqua Fortis*, and by corroding Copper turned it into a Bleuish Colour.

Afterwards we made a Solution of Minium in *Aqua Fortis*; and having by Filtration and Evaporation procured a *Saccharum Saturni*, we
Distilled

Distilled it in a well coated Retort, over a naked Fire, and obtained an offensive Acid which had the Smell of *Aqua Fortis*; which being put upon Minium, bubbled, and making a considerable noise, presently afforded a Liquor, from which might easily be obtained a true Sugar of Lead: Where it is observable, that the *Caput mortuum*, was neither Sweet, as before Distillation; nor Sower, as the Body drawn from it; but inlipid and easily reducible, by Fusion, into a malleable Lead.

In which *Experiments*, the following *Phænomena* are also Remarkable: First, that the Salt, which encreased the Silver in weight no more than a third or fourth Part, was able to Sublime the greatest Part of that fixed Body.

Phænomena to be observed in this Experiment.

Secondly, that the Parts of the same Liquor, being mixed with three several Metals, may produce as many different Tastes; tho' the same *Aqua Fortis* should be successively made use of in those three *Experiments*, and howsoever varied in respect of Order in the Tryal: And here we are to observe likewise, that Part of the Distilled Spirit of Nitre, being poured on the *Caput Mortuum* of *Saccharum Saturni*, turned some Parts of it into a Vitriol; and another Part of it being poured upon Filings of Silver, the Silver, being partly dissolved with a hissing Noise, was Coagulated into a Bitter Salt:

E X P E R I M E N T IX.

Because *Transmutation* of Bodies, whose Textures are esteem'd Primordial, as those of the Elements, and which are found to be Ingredients of most Compositions here below, will be a further Confirmation of the Possibility of Altering the Textures of other Bodies; I shall subjoyn, what Progress I have made, in order to turn Water into Earth.

*A Trans-
formation
of Water
into Earth.*

*Phenome-
na exhi-
bited.*

Having therefore in a Glass Vessel distill'd Fair Rain-Water, and several times re-distill'd it again; we found, that after every Distillation, there was a considerable Quantity of white Earth remaining at the bottom of the Vessel, which was more plentifully afforded in the latter Distillations, than the first; and therefore we had the greater Reason to believe, it could be nothing else but a certain quantity of Water, turn'd into Earth; which afforded the following *Phanomena*, viz. 1. Being put into a *Microscope* in the Sun-Beams, it appear'd to consist of Parts exceeding fine, which were as fine in the *Microscope*, as Hair-powder usually is to the Eye; yet not in the least Transparent. 2. Being mix'd with Water, it turn'd it into a whitish Colour, as the Powder of white Marble usually does; yet being settled in the Bottom, it remain'd undissolv'd. 3. After it had lain a considerable time in a Red-hot Crucible, it was neither diminish'd in quantity, nor did it in the least smoke. 4. It exceeded Water in weight, so as to be equal to twice its Bulk of Common Water, being almost as heavy as Wood-ashes, freed from their Salts; which,

to its Bulk of Water, is as 1 to 2½, which does not much come short of the weight of white Glas, which is twice and a half heavier than its weight of Water: So that from these *Phænomena*, we had Reason to term the Foremention'd white Substance, *Earth*; considering likewise its fixedness, and other Qualities.

But, further it is to be Observ'd, That the Glas in which it was distill'd, was not in the least damag'd by this Process: as also, That an Ounce of Water yielded six Drachms of Powder, a considerable quantity of Water still remaining behind.

Water alter'd
most wholly
convertible
into Earth.

So that this *Experiment* is no small Confirmation of our *Hypothesis*: For if *Elements* themselves may be Transmuted, and Artificially Destroy'd, by an Alteration of the Texture of their Parts; why may not Considerable Changes be effected also in other Bodies, by a Local Motion, and a New Manner and Form of Union of Parts, of different Figures and Sizes; since in this *Experiment*, the Parts of Water being modify'd a-new, form a Solid Body, of very different Qualities from what belong'd to it before, as want of Transparency, Solidity, &c.

As for the Manner of its being so modify'd a-new, it may easily be conceiv'd, That the Parts of Water, being put into Motion, and rubbing upon one another, by violent Occursions, might be so alter'd and adapted as to stick together, and to form several little *Molecules*, which being more condens'd, and consequently heavier than Water, could no longer swim in it; but obtain'd the several New Qualities before mention'd.

How Water
acquires
the Form of
a Solid
Powder.

And that the Change was thus effected, we have Reason to believe; since by a bare Circulation, in a just Degree of Heat, Quick-Silver will assume the Form of a Powder, which will not with so much ease be rais'd by the Fire, as the *Mercury* it self; but this will be further illustrated by the Tenth Experiment.

Inferences
drawn a-
gainst the
Doftrin of
the Chy-
mists.

Therefore to draw Inferences from this Experiment, which may disfavour the *Hypostatic* Principles of the *Chymists*; If Water be capable of being chang'd into Earth, by the same Reason the other Ingredients of Bodies may; and in the *Analization* of Bodies there may be a Transmutation of Substances, as well as a Separation of Pre-existent Principles. From hence also may be brought strong Arguments against *Helmont*; who, because he boasted of an *Alkabeft*, which, he says, would turn all Bodies into a Liquor, therefore concluded all Bodies were made of *Water*; for by the same Reason I might say, All Bodies are made of *Earth*; because *Water* may be turn'd into *Earth*: So that tho' he should turn all Bodies into *Water*, yet that *Water* being again capable of being disguised, it would only shew, That *Water* and *Earth* may be mutually Transmuted, by a successive Change of Texture.

But to leave these Reflections, I shall mention some Scruples, concerning this Transmuted Powder, which I could not have time to satisfy my self in: As, Whether the Water Remaining was lighter than before Distillation? Whether the Particles of Insipid Bodies, may act as *Menstruums* in the Dissolution of others? not but that they may be so chang'd in the Vessels of Plants, as to become sharp and powerfully penetrating.

netrating. Whether the Weight of the Glass-Vessel, was diminish'd by this *Experiment*? I should likewise be willing to be satisfy'd, Whether Water it self be truly a Homogeneous Body? which if it be, it will be strange, that without the help of a *Plastick Power*, or Seminal Principle, it should be so transmuted; since that a bare Convention of the Particles of a Fluid into a Concrete should alter their Specifick Gravity, is hard (if not impossible) to be parallell'd by *Nat.*

But in this *Experiment* it is further Remarkable, That Oyl of *Vitriol* pour'd upon this Powder, would corrode it, and that by an Effusion of Spirit of Salt there was rais'd a considerable Ferment; as when Spirit of Salt is put upon *Lapis Stellaris*: So that I suspected the Rain-water might be impregnated with some of the Sandy Parts of Glass dissolv'd, by the help of the Fire, and actuating the Particles of it; but this Suspicion was partly taken off, because I had observ'd the like Ebullition, upon a Mixture of Spirit of Salt with Wood-ashes, which were clear'd of their Salts in Boyling Water.

But to conclude this *Experiment*, we may further reflect upon the fore-going Suspicions; that if the Body of the Glass-Vessel were in the least dissolv'd in this Operation, it will be a powerful Instance of the Force of Insipid *Menstruums*; and it will be no less a Confirmation of the Doctrine of *Forms* and *Qualities* before deliver'd, that *Water* it self is subject to undergo such considerable Changes, as this *Experiment* shews it is.

I might produce a great deal more on this Occasion, to corroborate what I have deliver'd

concerning *Transmutations*; but I shall only add, that I, as well as two several Persons whom I employ'd, have without the Addition of any thing, obtain'd from Spirit of Wine, which was wholly inflammable, a considerable Quantity of Phlegm; and that too, without its being affected by any Visible Body.

EXPERIMENT X.

Considerable Changes may be wrought in Bodies by Mixture, and the Texture thence resulting.

To conclude this Chapter, I shall add an *Experiment*, to shew what sudden Productions and Alterations of Qualities may be effected by a *Coalition* of the smallest number of Ingredients, generally taken for Homogeneous Bodies; from whence it will appear, That the Changes of Bodies, in themselves considerable, may be effected by very easy Mixtures, *viz.*

Having by Degrees mix'd an equal weight of Spirit of Wine, and Oyl of Vitriol together, and plac'd them in a Bolt-head, stopp'd close with hard Wax, and a Cork; digest the Mixture in a Moderate Heat, for some time; then pour it out into a Glass Cucurbit, luting on a Head and a Receiver, to preserve the Subtle Spirits from flying away; then with a moderate Heat, draw off the Spirit of Wine, till the Drops begin to come over-sourish; then shift the Receiver, and carefully go on with the Distillation, increasing the Fire till as much is drawn off as you can, keeping the Substance remaining in the Cucurbit, in a Glass well stopp'd, and secure from the Air.

The

The *Phænomena* exhibited by this *Experiment* were the following: First, That the Spirit, first drawn from these two Inodorous Bodies, was endow'd with a Smell different from all others, and parts tho' pleasant and fragrant, yet very subtle and penetrating. Secondly, That the Liquor, drawn off last, had a very strong Sulphureous Smell, which stunk, and affected the Sensory, so powerfully, that it would almost take away one's Breath. Thirdly, This Mixture yielded a Liquor, which would mix with neither of the former; yet was very subtle, pleasant, and Aromatical. Fourthly, The Substance remaining in the Bottom of the Vessel, was Opacous, and almost as black as Jet, and withal very brittle. Fifthly, And tho' it was made up of two Liquors, the one corrosive, and the other inflammable, and both of very pungent Tastes; yet was it void of Taste, and could not without great difficulty, if at all, be brought to burn. Sixthly, Neither would it be mix'd for some Days with Water, tho' the Oyl and Spirit, readily diffuse themselves in that Liquor; besides, it was of so very fix'd a Nature that it would not be rais'd by a strong and lasting Fire, tho' both Oyl and *Viscid*, and Spirit of Wine be extreamly Volatile. And now,

Having thus in short laid down these *Experiments*, as sufficient Proof of the Doctrin before deliver'd, I shall conclude with this Reflection, *viz.* That in all the Changes and Alterations, that have been effected by *Art*, it appears, that they are so far from depending on the Imaginary Substantial Forms of the Schools, that they evidently appear to be the sole Effects of Local Motion, so altering the Figures and Sizes of the Mi-

nute parts of Bodies, or otherwise transposing them; as, upon a fresh Association and Coalition of them, to form New Concretes, of Textures very different from the former. And if *Motion*, *Bulk*, and *Shape*, together with peculiar *Textures*, be enough to cause so many different *Phænomena*, as have been laid down; there is no Reason, why other Qualities may not be produc'd by the same Fertile Principles; since all the Difference betwixt the Works of *Nature* and *Art*, in altering the *Forms* of Natural Bodies, lies in this, *viz.* That in the *Works of Nature* Active and Passive Bodies casually meet together; and in the *Latter* the different Substances, concern'd in every New Production, are brought together by an *Artist*; for in both the *Agent* acts as a *Natural Agent*.

CHAP. X.

An Experiment, with some Considerations touching the differing Parts and Redintegration of Salt-Petre.

S*ALT-PETRE* is a *Concrete* so universally concern'd in the Composition of most Bodies, that it will be of no small Import to *Natural Philosophy*, to enquire thoroughly into the Nature of it; which will in some Measure appear, by considering how many Substances may be drawn from it, or turn'd into it; which will be briefly intimated in the following *Experiment*.

Having,

Having, according to the usual Method, *Cry-* An At-
tempt to re-
dissolve the
Form of
Salt-Petre.
staliz'd Nitre, we melted four Ounces of it in a
Crucible into a Limpid Liquor, throwing in
Live-Coals successively, till it would kindle and
fulminate no longer; and continuing it in a
strong Fire a considerable time, to dissipate the
remaining Volatile Parts, and then breaking the
Crucible, we divided the fix'd Nitre immedi-
ately into two Portions; one of which being dis-
solv'd in as much Water as was sufficient, we
drop'd in Spirit of Salt-Petre, till the Ebullition,
rais'd by the Mixture of these Liquors, wholly
ceas'd; and then filtrating the mix'd Liquor, we
expos'd it to the Air in an open Glass-Viol;
and on the other Part undissolv'd, we likewise
dropt the same Spirit, till the Fermentation
ceas'd, exposing it to the Air in an open Glass-
Jar.

In the former Mixture, wherein the Water
was put, in a few Hours certain *Crystals* of Salt-
Petre stuck to the Lower Parts of the Glass,
amongst which were several other *Crystals*, like
Mustard-seed, encompass'd with a downy Sub-
stance. The *Crystals* the next Day being consi-
derably greater, were taken out, and both by
their Burning and Shape, appear'd to be Ni-
trous, (*Nitrous Salts* being furnish'd with flat
Sides, which when opposite are usually parallel;) and
as for that downy Matter which adhered to
some of them, we judg'd it to proceed from the
Disproportion of the Volatile and Fix'd Parts
of the Nitre, which were to be joyn'd together
a-new. These things being observ'd, we pour'd
the remaining Liquor into an open Glass-Vessel,
which in about three Weeks-time, being again
Satu-

Saturated with *Petre*, we pour'd it from the *Salt*, and evaporated it in a Digesting Furnace.

The other Mixture, which was only fix'd *Nitre* and Spirit of *Salt-Petre*, for the most part presently Subsided in the Form of a *Salt*, which when dry'd in the Air, was of very irregular Figures; and, in some Parts, not much different in Shape from *Salt-Petre*; which it also much resembled in Burning, tho' the Deflagration was in some measure peculiar to it self. But this *Salt*, together with the Liquor swimming upon it, being preserv'd in the Air for about a Month longer, after Evaporation, the one half shot into *Crystals*, which burnt much like *Petre*, and had a Similar Figure, tho' a different Taste; and the other half, being speedily exhaled, shot into *Crystals*, of a distinct Figure from all others.

Cautions to
be observ'd
in the Fore-
going Expe-
riment.

Now to make this *Experiment* clearer; the following Things are to be observ'd; 1. That in Fixing the *Nitre*, New-Coals are not to be cast into the Crucible, till the former are almost spent, or be thrown out by the violent Exhalations of *Nitrous* and Volatile Parts. 2. That the Quantity of Spirit of *Nitre* dropp'd upon the Fix'd *Nitre*, was almost proportionable to the *Salt-Petre*, spent in the Fixing of it. 3. That this Fix'd *Nitre* was very little different in Taste from *Salt of Tartar*; had the same aptness to Absorb Air, and to relaxate in moist Air: Yet it differ'd in Colour, being betwixt a Blue and a Green One, which it lost upon the Affusion of Spirit of *Nitre*.

Another
Method of
Reuniting
the Parts of
Salt-Petre.

But this Method being tedious, I shall propose a Way more expeditious, which is this; Having run Fix'd *Nitre per deliquium*, and by Filtration separated it from its *Feces*, we dropp'd upon the

the Liquor Spirit of *Nitre*, which, after a Ferment usual to a Mixture of those Liquors, presently shot into *Crystals*, in Shape, as well as Nature, manifestly *Nitrous*.

Another way we took was this: Having Impregnated a Solution of Fix'd *Nitre* in Water, with Spirit of *Nitre*, and filtrated it through Cap-Paper, the Cool Liquor, in a short time, shot into *Crystals*, like those of *Petre*; and the Liquor, being again Evaporated, afforded a fresh Quantity of *Crystals* not unlike the former. A Third Method.

But lest the *Salt-Petre* re-produc'd by the Coalition of these two Bodies, should be thought to lodge in the Fix'd *Nitre*; and only to be unyok'd by their Solution, it is requisite to annex, That the greatest Quantity that can be suppos'd to remain in the Fix'd *Nitre*, would not amount to such a Quantity as that Mixture affords: And to make the Matter less suspicious, we impregnated a Solution of Pot-Ashes, after the same manner as we had done the Fix'd *Nitre*, which after Filtra-
Salt-Petre obtain'd from Pot-Ashes, Aqua fortis, and Salt of Tartar.
 tion and Evaporation, shot into *Crystals*, which were very like *Salt-Petre* in Taste, as well as their Deflagration upon Live-coals. We likewise obtain'd a small Quantity of *Salt-Petre*, from *Aqua fortis* and Salt of Tartar associated.

But to draw Inferences from the Foregoing Experiment; from hence we may learn, That the Sensible Qualities of Bodies may be accounted for by the *Mechanical* Motion, together with the Figure and Disposition, or Modification of their Parts.

And first, tho' *Salt-Petre* be a Body inwardly, and in it self cooling; yet the Parts of it differently Modify'd, in our Experiment, being put
together

together, do immediately put each other into so violent a Heat, that I could with much ado hold the Glafs in my Hand; so that Heat seems to be nothing but a quick Motion of the finest Particles of Bodies, since it no longer continu'd in that Mixture, than the Parts of it were in Agitation.

Upon the Mixture of these two, viz. the Spirit of *Nitre*, with the Fix'd, there was likewise produced an audible Sound, proceeding from the Percussion of the Air, by the swiftly and impetuously agitated Parts of the Mixture: A Sound like to which is produc'd by a hot Coal cast into Water, or into melted *Nitre* in a Crucible, tho' the Latter causes a Sound much louder. Which Sound probably proceeded from the Percussion of the Air, because the Motion of a Bullet, or a Stick, where the Quickness of the Percussion puts the Air into an Undulating Motion, will cause a Sound, as soon as that Undulating Motion reaches the Ear; and it is further confirm'd, because that Sound no longer continues, than the Parts are violently agitated: And here it is to be observ'd, That the Sound, produc'd by the Mutual Conflict, ceases long before the Heat, which is acquir'd by that Ebullition; from whence it may be inferr'd, that the same Intestine Motion of Parts which are able to produce Heat, are incapable of causing Sounds; as *Amber* continues warm a considerable time after the Sound, made in rubbing of it, ceaseth.

Several
Qualities
flow from
an Altera-
tion of Tex-
ture.

We observ'd likewise, That the Fix'd *Petre* was of a Colour betwixt Blue and Green, which it presently lost upon the Mixture of the Acid Spirit, the Disposition of Parts being so alter'd,

as to reflect the Rays of *Light* differently to the Eye; A Change not unlike which happens upon the Exposing Fix'd *Nitre* to the Air: And it is not less to be admir'd, That *Soot*, which is Black, and a *Congeries* of *Opacons* Exhalations, should, by the help of a good Fire, fill the Receiver with Fumes as white as *Milk*: And the Colours to be observ'd upon the Sublimation of Black *Antimony*, and White *Sal-Armoniack* are no less pleasant.

But to return to the *Experiment*: Having not long ago attempted to make *Salt-Petre*, of *Salt* of *Tartar*, and *Aqua fortis*, the Mixture united, prov'd to be of a very Green Colour, which resid'd more peculiarly in some Parts of it than others, tho' the *Salt* of *Tartar* was a particular Preparation, whose *Crytals* were as white as *Sugar Candy*. It is on this occasion likewise further to be observ'd, That tho' Fumes of *Nitre*, rais'd by Distillation, be of a Red Colour; yet they condense into a Liquor altogether void of it; and also, That Fix'd *Nitre*, tho' an *Opacons* Body, yet does it unite, with the imbib'd Spirit, into *Diaphanous Crytals*.

There is likewise to be observ'd, Upon the Mixture of these two Ingredients, a very offensive Smell, caus'd by the Spirit of *Salt-Petre*, emitting stinking Exhalations, stirr'd up by the Mutual Conflict betwixt it, and its Fix'd *Salt*; where it is strange, that this Mixture should have a Smell, which is neither in *Nitre*, nor either of the Ingredients; and yet, that it should lose that Smell again, when turn'd into *Nitre*.

Besides the Taste of the Spirit, being strongly Acid, and the Taste of *Nitre*, like that of *Salt* of

Several Qualities destroy'd, and regain'd by the Redintegration of Salt-Petre.

of *Tartar*; it is surprizing, that these two should unite into a Body of so much less pungency in Taste as Nitre, bating that it is a little sharper by reason of some Spirituous Parts sticking to the Particles of the Nitre.

But besides these there are several other Reflections may be made on the preceding *Experiment*; for it seems a Question, whether there is any real necessity of a distinct Sulphur to render a Body Inflammable, or whether rather Inflammability depends on a disposition of Matter to be put into Motion by the help of adventitious Bodies; as when the Ingredients of our *Experiment* are mixed; or when a Piece of Iron is cast into Spirit of Nitre; for the Parts of that Liquor, which before were quiet and cold, meeting with Pores which disorder their Motion, they presently begin to move among one another with a strange Rapidity, and to cause such a Heat, that the Vessel would burn the Hands of them that held it: And here it may not be amiss to take notice of one thing further, that Occurs in our *Experiment*, viz. that tho' Nitre put upon a burning Coal, or a burning Coal being cast into it, will consume it self, in a Blue Flame, yet when it is contiguous to the Sides of the Crucible which is red Hot, it melts without the least Flame. It may be also worth Enquiry, why Nitre which is a solid Body should not rather stick in the Form of Sublimate to the Receiver, like *Sal Armoniack*, than condense only into a Liquor, which does not again coagulate as some Volatile Spirits do.

But leaving these *Phænomena*, I shall observe further, that though Spirit of Nitre, exposed to the

the Air Insensibly exhales, yet when associated with it's own fixed Salt, it admits no such Effluvi-
viums. Another thing to be observed is, that up-
on a Mixture of these two Liquors, several *Saline*
Parts are tossed out of the Glass into the Air,
which falling down again, several Grains of Salt
will remain on the outside of the Vial, which
will be visible if the *Experiment* be tried in the
Sun Beams. And that there is a very brisk Mo-
tion amongst the Parts of Spirit of Nitre, is
evident by dropping some of it into a solution
of Salt of *Tartar*; for immediately some Grains
were shattered in Pieces, and thrown up to the
top with a seeming Violence; till the strength
of those Liquors was mutually diminished by
their frequent Occursions: And that the Parts
of each have contrary tendencies in their Mo-
tions is plain, from this, *viz.* if when the Fer-
ment ceases, more of one of these Liquors was
dropped in, there followed no Ebullition, till
some of the other was added to Ferment with
it.

And here it is seasonable to observe what different Effects the Parts of these Bodies have when at liberty and disjoyned in Liquids, from what they produce when locked up in Con-
cretes, tho' their Effects, even then, are not wholly to be attributed to the briskness of their Motion, but also, to their determinate Sizes; by which means *Aqua Fortis*, which leaves Gold untouched, will dissolve Silver; yet, by an Addition of *Sal Armoniack*, it having acquired a new Figure, and a peculiar Motion, it Works upon Gold; and for the like Reasons a Solution of fixed Nitre will dissolve *Unknown* Bodies,

The same Particles of Matter have different Effects when in a Fluid, from what they have in a solid Form.

dies, which the Acid Spirit will not Work upon.

Again we may observe, that the several substances into which *Salt-Petre* is reduced, *viz.* the fixed Salt and the Volatile Liquor, are both different from the Concrete it self; which is an Argument against those *Chymists* that pretend, that Bodies Distilled, retain the Virtues of those Bodies they are Distilled from; for the Acid Spirit of Nitre will precipitate the same Bodies, which fixed Nitre dissolves. And so Spirit of Nitre will turn a *Tincture* of *Brazil* into a Yellow Colour, which it will lose, and in some Measure by an addition of a *Tincture* of fixed Nitre, regain the former, whereas a Solution of *Salt-Petre* changes neither of these *Tinctures*. But to proceed,

*Chymistry
rather de-
stroys than
discovers
the Princi-
ples of Bo-
dies.*

This *Experiment* gives us Reason to believe, that the Air is considerably concerned in the Production of *Salt-Petre*, and in giving a Figure to it's Salts; since the Crystals, which shoot in the Solution exposed to the open Air, are of a more exact Size and Figure, than those obtained after a quicker Evaporation. Besides which we have observed, that a Mixture of *Aqua Fortis* and Salt of *Tartar* yielded Crystals much more like Nitre, when it had been exposed to the the Air for some time, than what it afforded upon an immediate Crystallization.

As for the Reason why the Crystals which shoot in the Air, are more naturally Figured than others; I conceive it to be, because the Air is a more quiet and undisturbed Vehicle for them to move leisurely in, by which means they have the Liberty of uniting as they ought, to form Crystals of a natural Figure, which Guess

is confirmed, because the Crystals which shot in Water, where they have room enough, and an indifferent Vehicle, were more perfect than those, which were produced by a Mixture of the nitrous Powder and *Saline Spirit*, where they were forced, for want of Room, to Cry stalize, before they had time to Convene after a manner requisite to make them of a natural *Figure* and *Size*.

But to proceed: This *Experiment*, which shews how a Body divided into different substances, by Distillation, may be again united into an Original Concrete, will be a very strong and convincing Instance to prove, that the *Forms* and *Qualities* of Bodies depend on an essential Modification of their Parts; and that the difference observable in particular Substances, depends on a different *Texture*, and a Coalition of Parts of different *Figures* and *Sizes*; so that the *Redintegration* of Bodies is no more, but a restoring of their former Parts into the same Order and Position, being Artificially handled, so as to acquire their former *Sizes* and *Figures* in order to their Coalition.

Yet this I think necessary to be represented, viz. that the Composition of *Nitre* is so little Organical, that it will be hard to judge what success, in order to *Redintegration*, may be expected in other Bodies, where the *Fabricks* of them are so curious, by Reason of their numerous Ingredients, and the curious Contexture of them, that the latter is not to be imitated by Art, in the Production of Substances much less Organical, than the Parts of living Animals.

The last Observation I shall make on our *Ex- Chymical*
periment, is, That from what hath been said it *Medicines*
H may *laid aside*
spo rably.

may be thought that some Chymical Medicines may be too Rashly laid aside by some Physitians, who suppose, that the *Menstruums* made use of in their Preparations, are in some measure mixed with them; since, besides that those Salts may by care be washed away, several Parts of them may be so altered by Corrosion, that those, associating with other Particles of the Body they work upon, may degenerate into an innocent Concrete: An Instance of which we have in our *Experiment*, where a corrosive Spirit and a Caustick fixed Salt, unite into an innocent Medicine. And that Corrosive Salts may in a great measure be dulcified by their acting on other substances, is evident in a Mixture of Spirit of *Vitriol* and *Crabs Eyes*, or any other testaceous Body. And again, though Vinegar powerfully corrodes calcined Lead, yet uniting with it, it constitutes a Sweet Body, in which the sharpness of Vinegar is perfectly destroyed. And tho' it be an Argument usually alledged against the use of Medicines so prepared, that from several of them corrosive Particles may be drawn; yet since the same may be Effected by the Action of Fire upon *Salt-Petre*, the Objection is as invalid as the general Practice of Physitians can make it.

CHAP. XI.

Containing the History of Fluidity.

WHETHER *Fluidity* and *Firmness*, might not with more Reason be esteem'd *States* than *Qualities* of Bodies, or not; this is most certain,

certain, that they are to be accounted the most General Affections of Matter, all Bodies being either Fluid or Solid: If then these Qualities or States of Bodies be so General, it will be of moment to consider the Causes of them; and the rather in this place, because the Foregoing *Experiments* of *Salt-Petre* may serve to illustrate them.

To proceed then: A Body is said to be Fluid, because it consists of Parts, which easily slip upon one another's Surfaces to and fro, when mov'd, by Reason of the Porous *Interstices*, which remain betwixt those Parts, which they are made up of, they not being wholly Contiguous on every side; and also, because by Virtue of that Motion, they spread and diffuse themselves on every side, till oppos'd by some Solid Body, to the Internal Superficies of which, they presently adapt themselves.

And what Thoughts *Epicurus*, and the Ancient *Corpuscularians* had of *Fluidity*, will appear from these Verses of his Paraphrast *Lucretius*.

*Ille autem debent ex Lævis atque Rotundis
Esse magis, fluido quæ Corpore liquida constant.
Nec retinentur enim inter se glomeramina quæque,
Et procurfus item in proclive Volubilis extat.*

And indeed, we may rationally believe, That the Smoothness of their Parts may much contribute to the Fluidity of Liquors, as well as the Globular Figures of them; tho' there are several Fluid Bodies, whose Parts are of Figures very various, besides Flame and Air; the Figures of whose Parts are very irregular.

* And here we are to take Notice, That to render a Body Fluid, there is no need that its Parts should be so closely condens'd, as those of

H 2

Water,

The Definition of a Fluid Body.

• Bodies whose Parts are less condensed than Water, so be esteemed Fluid.

Water are ; since Flame and Smoke may be so manag'd, as to resemble Liquid Bodies ; of the Latter of which we have Proof, by blowing *Rosemary*-Smoke into a Glass-pipe, which, if when it is fill'd, the lower End be stopp'd, and the Pipe be held in a Perpendicular Line, the Surface of the Fumes will subside till Level ; and tho' the Pipe be inclin'd several ways, yet the Superficies of the Smoke answers to the *Horizon*, till the Glass be further inclin'd ; and then, the Smoke will run along the Pipe like Water, dispersing it self afterwards in the Air.

Minuteness
of Parts re-
quisite to
Fluidity.

But to return to the Cause of *Fluidity*: We conceive that there are Three things requisite to render Bodies Fluid : 1. The *Minuteness* of the Particles which constitute them ; by which they are dispos'd to an Intestin Motion, and to be preserv'd in it more easily ; as the Parts of *Lead*, *Quick-silver*, and *Gold*, when dissolv'd by a *Menstruum*, are easily rais'd and mix'd with the Parts of that *Menstruum*. Nay, *Fluidity* so much depends on the *Minuteness* of the Parts of Matter, which constitutes Fluid Bodies, that the Parts of *Antimony*, dissolv'd and broken into small Corpuscles, may be turn'd into *Butter* of *Antimony*; and, that *Butter* of *Antimony* is chiefly made up of the Substance of the *Antimony*, is evident, since by a Mixutre of fair Water, a white *Calx* will precipitate, easily convertible into *Glass* of *Antimony*. And *Nature* her self supplies us with further Instances ; since the very Substance of *Bones*, is, by Comminution in the Stomachs of *Dogs*, turn'd into a Liquor : And to confirm this Observation, I shall add, That I knew a certain Gentleman, who was a close Student, who liv'd for several

veral Days together without the least Drink, tho' in the mean time he sweat moderately, and easily enough, his Urine being agreeable to his Constitution, as the Urine of other Men's generally is to theirs: But that Solid Substances may yield, and be turn'd into Fluids, by a Commintion of their Parts, may be evinc'd by the Fusibility of Metals; since the more the Massy Particles of Metal are broke into small Parts, the more their Fluidity is encreas'd.

And here it may not be unseasonable to enquire, how it comes to pass, That a Transparent Liquor should be drawn from such Brittle Bodies as *Common Salt*; I know it is usually alledg'd, That the Fire only separates the Moist, from the Dry Parts; but since Bodies already Calcin'd or Melted, must needs by the Action of the Fire, have their moist Parts likewise so separated; it is rather probable, That the Fire only divides their Parts, and puts them into a violent Agitation, by which they are rais'd in the Form of Vapours, which falling into the Receiver, condense into a Fluid; whose Parts, by reason of their Shape and Size, being apt for Motion, continue to move up and down, and so preserve that Body in the Form of a Fluid, the Motion of the Air, or of some Interpos'd Bodies concurring to preserve the Parts of that in Motion likewise; and that the Air abounds with Parts, perpetually in a various Motion will appear by and by.

A Fluid may be obtain'd from a Consistent Body.

But in the mean time that a much greater Degree of Motion is requisite to preserve some Bodies in a Fluid Form than others, is plain, since several Bodies will be froze with one Degree of Cold, with which others will not; and tho' the Watry

Some Bodies more easily preserv'd fluid than others.

Parts of *Wine*, in some Countries, will freeze; yet the Spirituous Corpuscles of the same Liquor remain untouch'd: And tho' it is evident, by the help of good Weather-Glasses, that Cold condenses the Air; yet it was never so far condensed, as to become Ice; because the perpetual Motion concurring with the Minuteness and Shape of its Parts, they are always in an Agitation requisite to keep it in that Form; and it is not improbable, but that the Parts of *Salt* are very Minute; since, from *Experiments* before mention'd, it appears, That Spirit of *Salt* and *Urine*, will unite into a *Sal-Armoniack*; and it is further confirm'd, since, *Common-Salt*, mix'd with *Aqua fortis*, will dissolve *Gold*, as well as Spirit of *Salt* joyn'd with the Latter: and tho' Crude *Nitre* it self, be mix'd with Spirit of *Salt*, the Resulting Mixture will supply the Place of an *Aqua Regis*. And I am inform'd that, that a *Chymist* in *Holland*, drew no less than fourteen Ounces of Spirit from a Pound of *Salt*, a whitish Clay being made use of instead of the Common *Caput Mortuum*; and that when he had dephlegm'd the Spirit, twelve Ounces remain'd very highly rectify'd; which may be something in favour of *Beguinus*, who pretends to have got a Pound of Spirit from a pound of *Salt*. But it may be a Question, Whether the *Fluidity* of these Bodies may not in part proceed from the Action of the Fire, working upon some Parts of the *Concrete*; since a Phlegm or Water may be obtain'd from Rectify'd Spirit, so as to change Part of it into a moist Body like Water. And this will rather be thought probable, if we consider and believe what the Famous *Helmont* says, viz. That he could reduce
Oyl

Oyl and *Salt* into Insipid Water, without the help of that Noble *Alkaleſt*, which would render Groſs Bodies wholly Liquid.

The Figures of the Parts of Bodies, as well as their Sizes, contribute to their Fluidity.

And here it is requiſite to add, That it is not only the Sizes of the Parts of Bodies, that endues them with a Diſpoſition to *Fluidity*, but alſo, their Shapes; and I am the more confirm'd in this Opinion, becauſe, having diſtill'd *Oyl* of *Olives* in a Glaſs-Retort, *per ſe*, near a third Part of it was coagulated in the Receiver, into a whitish Subſtance, not very much unlike Butter; where the diſtill'd Subſtance, which uſually is fluid, tho' drawn from ſolid *Concretes*, was on the contrary in this *Experiment*, a Conſiſtent one, yielded by a Liquid; for which no other Reaſon can be given, but that the Shape of the Liquid Parts were ſo alter'd, as to become unfit for Motion.

But to return to the Reaſon of *Fluidity*, it is evident, That in pouring of Sand, Corn, Flower, Apples, Walnuts, &c. out of a Sack, that that Aggregate of Bodies, whoſe Parts are the leaſt, appears moſt like Liquids; and it is commonly obſerv'd, That Whites of Eggs, by being beaten with a Whisk, preſently loſe their Clammineſs and Viſciduity, and are reduc'd to a thin and fluid Subſtance, their Parts being broke aſunder, and more minutely divided. And I have obſerv'd, that That Jelly (which is by the Vulgar thought to fall from a Star) by being a long time digeſted in a well-ſtopp'd Glaſs, became a permanent Liquor.

Again, it is obſerv'd, That when *Silver* is to be caſt in Moulds, and to receive the Curious and Fine Impreſſions of Hair-Lines, the Metal is not only to be pour'd in very hot, but to be kept a Conſiderable Time in Fuſion, before it is thin

enough to run into those Lines, and to take exact Impressions of them; from whence it appears, That Bodies already fluid, may become more fluid; and the like Instances might be brought from other Bodies, as *Turpentine, Oyl, &c.* And if what *Helmont* asserts of the *Liquor Alkabeſt*, be true, viz. That it will turn all Substances, whether *Minerals, Metals, Plants, or Animals*, into a fluid Substance, of an equal Weight with each other; then it follows, That to divide a Body into Parts small enough, is enough to make it fluid. And to this I must add, that considerable Changes may be effected, meerly by a long Digestion in Vessels well stopp'd, and plac'd in a Convenient Heat.

Poroulness
in Bodies
requisite to
their Fluidity.

2. The Second Requisite to constitute a Fluid Body, is, That it should have considerable Vacuities or Pores, betwixt the Parts of it; for if there were no such Spaces, the Parts being put into Motion, would not have Space to continue it in, nor could one Particle by the Impulse of another, be forc'd to give way. But before I proceed, it will be requisite here to Note, That by *Spaces*, I would not be thought to mean *Vacuities* properly so call'd; but that there is no such Substance betwixt them, which will obstruct the Motions of the more Solid Parts.

This Caution being premis'd, I shall (to illustrate this Second Requisite) observe, That *Snow*, which is of an open and slight Texture, before it is compress'd, may soon be squeez'd into so close and compact a Lump, as to resist a very strong Pressure; the *Air*, which before was interpos'd betwixt the Parts of it, being press'd out. Again, we may observe, That when *Water* is clos'd up in a Bladder, and wants its Liberty to move in a yielding and free *Medium*, the Parts thus con-

confin'd together, resist Impressions like a Solid Body; and this *Experiment* I the rather made use of, than a Bladder distended with *Air*, because the Distention of that, might partly be attributed to the Spring of the Included *Air*.

But it is further to be observ'd, That tho' *How such Vacuities contribute of Fluidity.* such *Vacuities* are necessary to constitute Fluid Bodies, yet they are only so, to use *School-* Term, as *Removens, prohibens, i. e.* they prevent the Inconveniencies which must be the Consequence of a Plenitude, *viz.* Want of Liberty to move; or in other Words, as they dispose the Parts of a Body, to yield to each other's Motion. And here I would Note, That tho' in most Liquid Bodies, this Doctrin may take place; yet I conceive it not altogether absurd, to Question, Whether *Matter* may not be so exquisitely agitated and divided, as to fill up these *Vacuities*, and to be squeez'd into any Figure, as Occasion requires. But not to spend Time in examining this Point at the present, I shall proceed

3. To the Principal and last Requisite, in Modifying a Fluid Body; which is, That all the Particles of a Fluid Body, should be separately and variously mov'd up and down, either by Virtue of some subtle Matter diffus'd through their Substance, or an inherent Quality of their own. For the Difference betwixt Solid and Fluid Bodies, seems to consist in this, *viz.* That the Parts of Solids are at rest, and not so apt to yield to the Pressure of One's Finger, as the Parts of Liquids are, which are in Motion; since the Latter being already agitated to and fro, it is much more easy to guide that Motion, than to put the Parts of a Body into Motion; whose Parts, according
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A Perpetual Motion if Parts requisite to Fluidity.

to the Laws of Motion, must be at rest, till mov'd by an Agent powerful enough to put them into Motion.

But when once they are put into Motion, by the same Laws, they must continue so, till stopp'd by some other Body; and consequently, they must be in a perpetual Change, as to their Places and Order: so that hence it appears, why some Bodies come to be so soft, since such small Parts of Matter, being in Perpetual Motion, must needs yield very easily to the Touch, and give way to the Impressions of other Bodies. And also, it cannot but dispose them easily to be confin'd by the Vessels they are contain'd in, and as apt to disperse themselves, when Liberty is given them.

Having premis'd this Brief Account of *Fluidity*, I shall now proceed to illustrate it by *Experiments*: And first, by that concerning *Salt-Petre*.

*The Doctrine
of Fluidity
illustrated
by Experi-
ments.*

Salt-Petre then may become a Fluid Body, either by having the Particles of it dissolv'd in Water, so that they may move up and down, and to give way to the Impression of an External Agent, as the other Parts of that Liquid do; or it may put on a Liquid Form, by being expos'd to the Air in a moist Cellar, where by running *per Deliquium*, the *Salt-Petre* will be dissolv'd, and put on so far the Form of a Liquid, as to have all it's Parts in an Agitation, sufficient to rank it amongst Fluid Bodies.

But *Salt-Petre* may put on a Liquid Form, without the Addition of a Liquid Body; as first, It may be reduc'd to so fine a Powder, as to resemble a Liquid, in the pouring of it out of one Vessel into another, besides the other Requisites of

of a Fluid Body; viz. That it hath Vacuities betwixt its Parts, and that they may be easily put into Motion; only they differ from the Parts of Liquids in some Respects, since the Powder hath not it's Parts always in Motion; besides the Vacuities are more sensible: But notwithstanding, if by the force of Fire each of these Parts be again subdivided, those insensible Corpuscles, being violently agitated, make up a Fluid Body: So the Particles of Metals, being by the same Agent seperated and put into Motion, do not only move variously one amongst another, but are sometimes tofs'd a considerable height into the Air. And not only Fire, but some other Bodies, which are sensibly Cold, may, provided the Texture and Motion of their Parts be rightly dispos'd, reduce several Substances to a Liquid Form; so *Camphire* puts on the Form of an Oyl, when swimming upon *Aqua fortis*: And when *Salt-Petre* is by the Action of Fire, endow'd with a Fluid Form, it is equally a Fluid, as when incorporated with Water, there being very little difference betwixt these two States of *Nitre*; only that in the Former, the Agent, which keeps the *Nitrous* Parts in Motion, is more Volatile and Brisk, and divides it into smaller Parts, without making an Addition to its Bulk.

But, perhaps, it will be a Scruple, Whether the Powder of *Nitre* be an Imperfect Fluid, when pour'd out, or rather like a heap of Sand, not reduc'd to a permanent State of Fluidity: To remove this Scruple, we may take Powder of *Alabaster*, or instead of it, Plaster of *Paris*, and we shall find, that by putting it into a hot Vessel, by the continued Action of the Fire, the Parts of
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that Powder will be so agitated, and, by the Assistance of the more Spirituous Parts, kept in Motion, as to Boil and emit Steams like a Fluid Body, and altogether resemble a Coherent Substance; yet, if it be remov'd from the Fire, it again subsides in the Form of a Powder, tho' for once again it will assume the Form of a Liquid, if expos'd to a competent degree of Fire; yet when the Ebullition of the Parts of it are most violent, if a small Portion of it be thrown upon a piece of Paper, it appears to be nothing but a very fine Powder: From whence it is evident, that Fluidity depends on a vehement and various Agitation of Parts; which Fluidity the same Body may be depriv'd of, by losing that Intestine Motion.

What the Motion of the Parts of Fluids depends on.

And thus it briefly appears how much Motion contributes to the Fluidity of Bodies. And here, tho' it would be very desirable to determine what is the Essential Cause of that Motion; yet since it is a Matter of too much Intricacy, it being by some held to be inherent in Matter, and by others to be promoted by Impulse, I shall rather pass it by, than enter upon an Examination of those two Points; especially, since there would be the same Necessity of Discussing others, which equally relate to the *Cartesian* Principles: It may therefore suffice in short, that neglecting the Unintelligible Doctrin of *Substantial Forms*, we rather ascribe it to those *Catholick Affections* of *Matter, Motion, Shape, and Situation*.

But to omit what we have elsewhere deliver'd concerning these *Catholick Affections* of Matter, we shall observe, what this *Experiment* further affords us: We are therefore to take Notice, That there

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is a difference remarkable betwixt a Fluid, and a Body which hath a Quality of Wetting Bodies which are Contiguous to them; since every wet Body is Fluid, but not *vice versâ*: For Air, Flame, Melted Liquors, or *Salt-Petre*, tho' fluid, are all void of a Wetting Quality.

Whence we are led to consider, That *Humidity* is but a Relative Quality, depending on the Congruity that one Body hath to stick to the Pores of another; whence some Fluid Bodies, whose Parts are not adapted, so as to adhere to the Pores of other Bodies want that Quality, as *Quick-silver*, which slips over the Surfaces of most Bodies, without sticking to them; tho' in Respect of some (as *Gold* or *Tin*,) it may be esteem'd Fluid; since, inasmuch as it dissolves them, it hath much the same Virtue as Liquids have in softening other Substances: And that Humidity depends on an apt Configuration of the Parts of Matter, and their Congruity with the Pores of other Bodies, is further evident, since Water it self, in respect of some Bodies, is not moist as the Feathers of *Swans*, *Ducks*, &c. Add to this, That it is further observable, that when the Texture of a Liquor is chang'd, it may adhere to Bodies it would not stick to before: As for Instance, Tho' neither *Quick-silver*, *Lead*, *Tin*, or *Tin-glass*, will stick to *Glass*; yet a due Proportion of each mix'd together will presently, without the Assistance of Fire, adhere to it.

But further: If it be objected, That the Insensible Agitation of the Parts of Fluid Bodies, are but Imaginary and Precarious; since the Smallness of them, makes them too fine to appear: I must answer, That since their Vacuities, are

Humidity a
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so small as not to be Visible, it is as impossible to discern their Parts, and consequently the Motion of them; since one Part is so presently succeeded by another, that the Eye hath always a whole heap before it, tho' separated by Pores so small as to be undiscerned. And tho' the Vacuities betwixt the Parts of powdered *Nitre*, be so large, as to be discern'd by the Eye; yet when it's Corpuscles, by the Action of the Fire, are render'd more Minute, not only *Salt-Petre*, but *Gold* also, are said to possess a less Space, and consequently must leave less Vacuities betwixt their Parts, and which are altogether In-visible to the Eye: For which reason the Body appears continuous.

The Motion
of the Parts
of Liquids
variously
determin'd.

And that the Particles of Fluid Bodies, are in Motion, variously determin'd, appears from their Effects; since they not only penetrate, but putrify some Bodies, and presently dissolve them; as when *Sugar* is cast into Water, that sweet Substance is dissolv'd, and its Parts so much associated with those of the Water, as to be carry'd up to the Top of it; which is further observable in *Sea-water*, whose Salts upon Evaporation swim at the Top of the remaining Liquor; and it is not less remarkable, That a Solution of *Gold* in *AquaRegis*, will presently Tincture twenty times as much fair Water: And further, That the Particles of Flame may be discern'd to move very fiercely, even by the Eye, is commonly known, and further confirm'd, both by their Operations, and the Rays which every way expand themselves, and strike against the Neighbouring Bodies. And that the Air hath it's Parts in a constant Motion, variously agitated,

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we have a great deal of Reason to believe; since we may easily discern whole swarms of *Motes* swim up and down in the *Sun-Beams*: and not only so, but in clear *Sun-Shine Days*, we may perceive on the Walls of Churches, and other Spacious Buildings, certain obscure Shades to quiver and tremble: And we have yet a further Instance in *Salt of Tartar*, which, after Fusion, being for a considerable time left in a moist Cellar, will dissolve, and put on the Form of a Clear Liquor, by imbibing the Moistness of the Circumambient Air, which penetrates, and gets into the Pores of the *Salt* by an Instinct and Powerful Motion. And it is further to be Noted, That if in Summer, cold Water be put into a Glass, the moist Vapours which move about it, will be condens'd on the outward side of the Glass, and appear in the Form of *Dew*, those Moist Particles, which swim in the Air, being, by the Perpetual Motion of it's Parts, successively driven upon the External Superficies of it: In trying of which *Experiment* it is Remarkable, That the *Dew* on the out-side, was not to be observ'd above the Surface of the Liquor contain'd in it. And these Relations are the less to be wonder'd at, if we consider, that so weighty a Body as *Lead*, may be rais'd in the Form of Smoke, a considerable height into the *Air*, by the Assistance of proper Vessels, plac'd in a convenient Furnace; which Smoke, will be soon scatter'd and dispers'd, by the Various Motion of *Aerial* Particles: And this *Experiment* does not only shew, that the Parts of *Air* are in a Perpetual Motion, but also how much the Minuteness of them contributes to their *Fluidity*.

And

And tho' *Quick-silver* much exceeds any other Body in Weight, except *Gold*, yet it's Minute Parts, agitated and rais'd in the Form of a Vapour, will, like other small Particles of Matter, glide to and fro in the *Air*; whence it hath often-times happen'd, that in Evaporating of it, several pieces of *Gold* have been so whitened over with the Fumes of it, as not to be got off again without a great deal of Trouble.

But to make it almost Visible, that the Parts of *Liquid Bodies*, are perpetually in a variously determin'd Motion, mix a Solution of unrefin'd *Silver* in *Aqua fortis*, with 15 times its Proportion of Fair Water, Decanting or Filtrating the clear Mixture: In which Liquor the Parts of the *Silver* are not in the least discern'd, tho' upon Immersing a Copper-Plate into it, the Particles of that Metal, which before swam up and down in the Mixture, presently adhere to the Copper, and crust it over with a Metalline Powder; and if the Copper Plates remain in that Liquor for a Night, the whole scatter'd Corpuscles of *Silver* will be collected together about them, the Liquor being Tinctured with a Blue Tincture, by some Parts of the Copper, corroded and divided into Parts, by the Salt Parts of the *Aqua fortis*. And to render this *Experiment* still more Useful, I have observ'd, That by letting a piece of *Spiltre* lye in this Tincture for some Days, the Copper Particles were gather'd round about that also, from all the Parts of the Liquor; which could not be, were not the Water in a Perpetual Intestin Motion; so that its Parts might, by often changing their Places, successively

cessively strike against the *Spelter*, and so leave the *Silver* behind.

To this *Experiment* may be added another, which I have long since try'd, when first I began to consider the Reason of *Fluidity*. I drop'd then, into Spirit of *Wine*, moderately Deslegm'd, a small quantity of Oyl of *Turpentine*, letting it fall so far, that it might by the force of it be broke into small Drops, which by reason of their Tenacity, being unapt to mix with the Spirit, would swim upon it, and be mov'd up and down, variously and irregularly, by the Spirituous Parts of the Liquor, which struck against them in their Ascension; and whilst these Spirituous Parts continue to exhale, it is pleasant to behold, how the Globous Parts of the Oyl will sometimes be gather'd together, and almost unite, and presently after, be again dispers'd abroad, and move to and fro amongst one another; and this Motion would continue, till the most Agile and Spirituous Parts of the Liquor were wholly spent. And lest this Motion of the Oyl Parts, should be suspected to arise from some *Antipathy* betwixt it and the Liquor, I try'd the *Experiment* with small chop'd Straws, which were likewise impetuously, and confusedly mov'd up and down on the Superficies of the Spirit: From whence we may learn, That there may be an Intestin Motion of the Parts of a Liquid Substance, tho' it be not discern'd by the Eye. I might here reckon up a great many more *Phænomena* exhibited by this *Experiment*; but it shall suffice to take Notice, besides what hath been already deliver'd, That some of the aforementioned Spirit, being clos'd up in a Glass;

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Hermetically seal'd, to try whether the Oyl Drops would continue their Motion, when the *Vinous* Spirit could not exhale, the Vessel was presently broke, without any force otherwise discernible, than by the effects of it.

And that the small Parts of the most weighty Liquors, are actually in a Continual Motion, may not only appear from what hath gone before, but may be further confirm'd; since *Quick-silver* will not only penetrate into the Pores, but destroy the Texture of so solid a Metal as *Foliated Gold*: And *Salt of Tartar*, tho' cold, is able to extract Tinctures from several Bodies: And that the Parts of Oyl of *Vitriol* are in a Perpetual Motion, may be evinc'd, by the Corrolive Qualities of it, which it powerfully exerts without the Assistance of Heat, not only in Corroding Metals; but if pieces of *Camphire* be thrown into it, they are presently turn'd into an Oily Substance. And whoever is unwilling to believe that there is an Intestin Motion of Parts in these two Oyls, may easily be undeceiv'd, by the Heat and Ebullition, which follows upon the Mixture of them agitated together in a Glafs.

But here we are to observe, that tho' it be an Essential Property of *Fluid Bodies*, that one Particle readily gives way to another; and that the other is as apt to succeed in the Place of it interchangeably; yet that is not to be conceiv'd of all *Fluid Bodies* in General; but is to be understood only in such Bodies, as are either Simple and Homogeneous, or as have an Aptitude to mix with each other, as Wine and Water; since there are some Liquid Bodies, which will not be mix'd together; but like compact Substances,
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resist the Impressions of each others *Superficies*; and it is not a little strange that *Lucretius* and some other of the Antient *Atomists* should overlook so obvious an Observation, since it is apparent in Oyl, which will not mix with Water; but more eminently in *Quicksilver*, which denies to mix any of those Liquors which were familiar amongst them.

But to add an *Experiment* which is more remarkable, having so prepared and opened the Body of Copper with a sufficient Quantity of *Salt Armoniack*, as to render the prepared *Mineral* inflammable; I applied some Grains of it to the Wick of a *Candle*, by the force of whose Flames it was not only Melted, but carried up along with the *Tallow* to the Bottom of the Flame; where it was observable, that the Flame of it was both lasting, and as distinct from that of the *Candle*, as if the two Flames had been separated by the Interposition of some other Body.

But to return to what I have said of the unaptness of Liquors to mix with one another, the reason in general seems to be no other than the particular *Texture* and peculiar *Motion* of their Parts. And this I am the rather induced to believe, because *Salt of Tartar*, dissolved by the moistness of the Air into a *Liquid Form*, will readily mix with *Spirit of Wine*, the *Texture* being only changed by an addition of Water; tho' before, they both had their distinct *Superficies*; and tho' mixed by a Violent Motion, yet would presently separate again, and each regain it's former Position. And Oyl or *Spirit of Turpentine*, gently drawn off from *Sea-Salt*,

Why some Liquids are unapt to mix with each other.

Melted or well *Decrepitated*, will readily mix with *Spirit of Wine*, though there was no sensible difference betwixt that Oyl and another which would not. Again, a Solution of *Salt of Tartar*, digested for some time with Oyl of *Almonds*, would be turned into a soft *Sapony* Substance; tho', by a strong *Agitation*, *Lixivial* Liquors cannot be mixed with Oyls. Moreover, tho' cold *Quicksilver* will not mix with Oyl of *Vitriol*, yet, the boiling Oyl will, by piercing it's Substance, both alter and incorporate with it.

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determi-
nate Figure.

There remains one thing, yet to be taken notice of concerning the Difference in *fluid Bodies*, which is, That some of them, which will touch each others *Superficies* without Mixture, will also reduce them to a determinate Shape. As for Instance, if *Spirit of Wine* be poured upon Oyl of *Tartar per deliquium*, tho' the contiguous *Superficies* of both be parallel to the *Horizon*, yet the upper *Superficies* of the Spirit will be endued with a visible Concavity, if the Experiment be tryed in a slender Glass unstopped. In which Liquors it may be further noted, that upon a Mixture of Oyl of *Almonds*, it presently separated the one from the other, the *Superficies* of the Oyl of *Almonds* contiguous to the Oyl of *Tartar*, being Level as well as that, which was next to the *Spirit of Wine*: But if Oyl of *Turpentine* be poured upon it instead of Oyl of *Almonds* it will be divided into several Portions, some of which Swimming in the *Spirit of Wine*, will be of a Globular Figure, and others which rise to the top of the Liquor, will be partly Level with the *Superficies* of the Liquor,

Liquor, and partly *Spherical*, on the immersed *Superficies*. And it may be yet further observed, that some Globular Parts would, tho' the Liquor was shaken, continually Swim upon the Oyl of *Tartar*, being contiguous to it only in a Point. But what is more Remarkable is, that several drops of Oyl of *Turpentine* falling into the *Spirit of Wine*, lay upon the *Superficies* of the Oyl of *Tartar*, like so many Hemispheres, their convex *Superficies* being upwards; yet by degrees they became *Globular*, being equally pressed on every side, and touching the Oyl of *Tartar* only in a Point. And these *Experiments* I have the rather recited, because, they being added to that which may be observed in the *Torrecellian Experiment* by suspending *Mercury* in the Air (by admitting Air into the Glass Tube, so as to separate the *Mercurial* Pipe into several Short ones, which will have on each side a *Superficies* something convex) because I say, they might be of Use in Accounting for the different Configurations of *Fluid Bodies*, as well as the distinct *Superficies* of those Vapours which Swim in our *Atmosphere*.

Having said thus much of *Fluidity*, it may *ATran.³* not be amiss to subjoyn one *Experiment* which *transparent Li-* shews, how a transparent Liquor may be divi- *quor may* ded into two, the one *Diaphanous*, and the other *yield a Li-* *quor Dia-* *phanous* *and another* *Opacous*. Pour into a warm Solution of an Ounce of *Quicksilver* with a double *Quantity* of *Aqua* *Opacous*. *Fortis*, about half an Ounce or an Ounce of Filings of Lead, being cautious that it be not put in so fast, as to make the Liquor Boil over; the Event of which will be, that the Lead will be immediately precipitated in the Form of a

white Powder, the *Mercury* running together again into a *Fluid Body* immerfed in the *Aqua Fortis*. And here it is to be noted, that if the fuccess of this *Experiment* be frustrated, the *Mercury* may by degrees be again recovered if the white Precipitate be diligently ground for some time with Water.

*Motion in
the Parts of
some Consis-
tent Bodies.*

But to put a Conclusion to this Chapter, it is highly probable, that not only Fluid, but some consistent Bodies have their Parts in a certain degree of Motion; whence, as we may conjecture, proceeds that Dust which is the Effect of Putrefaction, in some sorts of Wood: And it is not absurd to imagine, that from hence Worms in Fruit as well as Magots in Cheese derive their Original. And that there is Motion amongst the Parts of some consistent Bodies, is further made probable, both by that *Turpentine* which I have observed to Sweat out of Deal Boards, and the growth and increase of the Bones, and other consistent Parts of Bodies; but more particularly in those of colder *Animal Substances*; as *Oyster-Shells*, *Crabs-Claws* and such like consistent Substances.

Having said thus much concerning *Fluidity*, it might not be improper to take notice how by the Mixture of Liquids, their *Fluidity* is sometimes promoted, and also sometimes destroyed. But since we shall have occasion sometime or other in the following Chapter, to make such Observations; I shall, to close this Chapter, add an *Experiment*, which may intimate, that the event of Mixtures is not always certain: The *Experiment* is the following; We Evaporated a Solution of *Copper* in Spirit of *Nitre*, from whence

whence we obtained a *Vitriol* of a lovely Colour: We likewise dissolved one Part of good *Tin* in a double *Quantity* of *Spirit* of *Nitre*; and tho' *Salt-Petre* as well as *Tin*, be both *Fusible*, yet this *Metalline Mixture* would neither melt on quick Coals, nor in a red hot *Crucible*: Whereas the *Vitriol* of *Copper* would melt with the heat of ones Hand, though the *Metalline Ingredients* be much more hard to be brought to *Fusion* than *Lead*, or even *Silver* it self; and we have sometimes obtained such a *Vitriol*, as might be preserved in a *Fluid Form* by the *Languid* heat of the *Sun* in *Winter*, either with *Spirit* of *Nitre* or a certain *Aqua Fortis*: From whence it appears, that the *Textures* of *Compositions* are to be considered, as well as the *Particular Consistence* of the *Ingredients*.

CHAP. XII.

Experiments concerning the Superficial Figures of Fluids. Especially of Liquors Contiguous to other Liquors.

Considering that the greatest Part of the Universe, is made of *Fluid Bodies*, especially if according to the *Cartesian Hypothesis*, the Sun and fixt Stars consist of *Fluids*, it may not be amiss to illustrate, what we have only hinted at in the foregoing Chapter: For the following *Experiments* made about the superficial Fi-

gures of *Fluid Bodies*, may not a little contribute to illustrate, as well what hath been before delivered, as what hath been said concerning the Pores of *Fluid Bodies*; besides, they may be of no small use, in accounting for several *Phænomena* belonging to the *Grand System* of the World.

EXPERIMENT I. and II.

The Figure
of the Sur-
face of a
Nitrous Li-
quor.

To try whether the concave Surface of *Fluids*, contained in a Pipe, was wholly to be attributed to the Pressure of the Contiguous Air, I poured *Dephlegmed Spirit of Wine* upon a strong *Alkalizate Menstrum*, which was made of fixed *Nitre* run *per deliquium* in a moist Celler, and contained in a *Cylinder of Glass* of about a quarter of an Inch *Diameter*; I found that the *Menstrum* changed it's concave for a horizontal *Superficies*; and the like succeeded in a *Glass* of a much greater *Diameter*. And that *Superficial Cavity* was likewise almost destroyed by pouring on Oyl of *Turpentine* instead of Spirit of *Wine*.

EXPERIMENT III.

Of Water.

If instead of the former *Liquor*, common *Water* was put into the *Glass Cylinder*, it retained it's former Surface, tho' Oyl of *Turpentine* Swam upon it instead of Spirit of *Wine*.

EXPERIMENT IV.

To try what Surface would be made by an
Oyl

Oyl heavier than Water, by being contiguous to it, I put pure Oyl of *Turpentine* into a Glafs Cylinder, and found that the Concave Superficies which it had whilst the Air was Contiguous, became Convex and protuberant upon an Affusion of Water.

EXPERIMENT V.

Again having put Salt of *Tartar deliquated* in-^{The Superfi-} to a Glafs Cylinder, and poured Oyl of *Guajacum* ^{cies of a So-} upon it, we found, that the Concave Superfi-^{lution of} cies was not altered as it was by Oyl of *Turpentine*: And having gently poured Water upon these two, the Oyl of *Guajacum* swam betwixt the Water and the Oyl of *Tartar*, having a Convex Superficies at each end, that next the Oyl of *Tartar* being most protuberant.

EXPERIMENT VI.

Having likewise put Oyl of *Cloves* into a Glafs Cylinder; by pouring Water upon it, it's Concave Superficies presently became Convex; and this Oyl being too heavy to swim upon Water, we poured some of it upon ^{Of Oyl of} *Deliquated* Salt of *Tartar*, pouring upon it likewise a little common Water, which being done we found the Oyl *Protuberant* at both Ends, but more at that which was Contiguous to the Water.

EXPERIMENT VII.

Again, having put a considerable Quantity
of

Of Quick-
silver.

of *Quicksilver* into a Pipe of the same *Diameter*, but much longer than the former; we found, that the *Superficies* of it, which was otherwise considerably *Protuberant*, was in some measure Depress'd, when Water instead of Air was Contiguous to it.

EXPERIMENT VIII.

Of the same.

Upon tryal, whether a greater or less Quantity of Water would alter the Surface of the *Mercury*, I found that the greater the Quantity of Water was, the more it was depressed; tho' it did not always succeed: But when the Cylinder, being of a considerable length, was filled with Water, the *Mercury* Contiguous to the Glass was depressed to a Level; having, in the Center of its *Superficies*, a *Protuberance Semicircular* and raised above the other level Surface half its *Diameter*, which *Protuberance* gradually subsided as the *Mercury* was drawn off.

EXPERIMENT IX.

The Surface
of Liquors
in Vacuo
Boyliano.

Having conveyed two of the afore-mentioned Cylinders, one containing Water, and the other *Mercury* into our Pneumatical Receiver, we found that, notwithstanding the Air was not Contiguous, the *Superficies* of the Water was not manifestly altered by the Exsuction of the Air, tho' the *Mercury* seemed sometimes to be a little more *Protuberant*, especially when the Exhausted Air was let in with any Celerity. But one thing in the *Mercury*, which was

was observable; was, that upon the *Exsuction* of the Air, several Bubbles seemed to rise in the *Mercury*, and how much those might conduce to the mentioned *Phænomenon*, we leave others to try. Again, having conveyed another Cylinder into our Receiver, which contained an Oyl, whose *Superficies*, when Water was poured upon it, was Convex; we found, that upon the *Exsuction* of the Air, neither the Oyl lost it's *Protuberant*, nor the Water it's concave *Superficies*: From which *Experiments* it may appear, what Effects the Pure *Aether* would have upon such Bodies, were they remov'd out of this *Atmosphere*.

E X P E R I M E N T X.

Though the Figures of the Parts of scatter'd *Fluids*, and of condensed *Vapours*, be usually Globulous; yet those Observations being too Transient, to deduce from them the Figures of the Parts of *Fluids*, we tryed the following *Experiment*, that I might observe something more Remarkable: Having mixed *Fixt Nitre*, dissolved into a Liquor by running *per deliquium*, with exactly rectified Spirit of Wine, and found that, those two Liquors, tho' shaken together, would retain distinct Surfaces; I drop'd Oyl into the Spirits, which gradually subsided till it touched the *Superficies* of the *Nitrous* Liquor. The *Phænomena* exhibited by this *Experiment* were the following.

I. That if the Drops were small, they retain an exact Spherical *Figure*, being neither depressed by their own weight, nor the gravity of the

Phænomena exhibited by a *Nitrous* Li-

quer and
Spirit of
Wine.

the ambient Spirit, the Oyl being much of the same specifick Gravity with the Spirit of Wine.

II. If an Aggregate of Drops were a quarter of an Inch in *Diameter*, the Pressure of the upper Parts would depress the lower so much as to form a Plain on that side Contiguous to the *Nitrous* Liquor, so that the *Horizontal* exceeded the *Transverse Diameter* in Length.

III. And if the Quantity of Oyl was greater, it would so depress the lower Parts, as to form an imperfect *Hemisphere*, the lower Part of it having it's plain and horizontal *Superficies*, parallel to that of the *Superficies* of the *Nitrous* Liquor.

IV. But if the Oyl poured in, was moderate as to Quantity; tho' at the first it would spread over the Surface of the *Nitre*, yet, by degrees, it would be compress'd and be so raised, as to form either an *Hemisphere* upon the Surface of the *Nitrous* Liquor, or a Segment of a Globe, or even of an Imperfect *Ellipsis*; to the production of which *Phenomenon* the Tenacity of the Oyl, as well as the Ambient Spirit in some Measure contributed.

V. Tho' these Globules of Oyl would sometimes readily mix and associate, when brought together; yet, for the most Part, they would make an Impression into one another without uniting, and again recover, their former Figure when permitted to separate.

VI. It was not unpleasant to behold, how if a large Quantity of Oyl was poured into the Spirit, the Convex *Superficies* of it would acquire various *Figures* upon the Motion of that Ambient

bient Spirit; and if the Agitation was strong, several Parts being broke off, would form as many Aggregates of a Globular Figure.

E X P E R I M E N T XI.

Having put a Mixture of two Oyls, one of which was drawn from *Turpentine*, into other Liquors, to try whether the Lighter Oyl would separate from the heavier, with which it was incorporated; I found, that tho' it answer'd not my Expectation; yet as the Quantity of either of the Oyls was prevalent; the Mixture would either sink or swim, in the Liquors it was put into. And to the *Phænomena* exhibited by Oyl of *Turpentine*, it may be added, That when part of it is contiguous to the Liquors it is put into, and part adheres to the Glass, the Superficies contiguous to the Water is of Figures too various and extravagant to be described.

E X P E R I M E N T XII.

It is to be noted, that when the *Nitrous Li-* Several Colours exhibited.
quor is very clear, it will, in the former *Experiments*, be very difficult to discover where the Surfaces of the two Liquors are contiguous, they both appearing to be one and the same Mass, except some Dust swims upon the *Nitrous Liquor*, or the Rays of Light fall obliquely upon it.

E X P E-

E X P E R I M E N T XIII.

Having pour'd a peculiar sort of Oyl upon a Deliquation of *Nitre* and *Tartar*, ting'd with *Cochinele*, I observ'd, that by holding the Mixture in a certain Position, the plain Superficies not only variously refracted the Incident Beams of Light, so as to represent several vivid Reflections, but the plain Superficies appear'd almost as convex, as that of *Quick-silver*; and it was further to be observ'd, That it almost as strongly reflected the Rays of a Candle, as a Close Specular Body usually does; which *Phænomena* could not proceed from the *Alkali* altogether, but might partly from the Concurrent Action of the Oyl, which I observ'd to contribute to Refraction, when mix'd with other Liquors; but I shall not here endeavour to determine, what was the Cause of the Foremention'd *Phænomena*; but in order to it shall observe, First, that neither the Confining Plain, which separated these two Liquors, nor the Superficies of the *Nitrous* Liquor, was the Occasion of that Red Colour, which the Flame of the Candle acquir'd. Secondly, the Liquor being chafed, the uppermost would be turn'd into a Froth, consisting of Bodies imperfectly Globular, which in a little time would form a rude *Physical* plain, the Upper Superficies of which, would reflect the Rays of Light very briskly; and when the Parts of the Froth became a little finer, they would reflect the Rays of a Candle, so as to represent so many pieces of *Silver* polish'd, or a Copper Plate freshly immers'd in a Solution of *Silver* in *Aqua fortis*: To which *Phænomena* a Third may be added, viz.
That

That the confining Surface of the aforementioned Oyl upon Spirit of Wine, was not a little strongly reflective. Most of these *Phænomena* before mention'd, were afforded, by making use of Oyl of Limons instead of the former, except that the Reflection was not so brisk.

E X P E R I M E N T XIV.

Having pour'd Oyl of Aniseeds dissolv'd by a Moderate Warmth, upon warm Water, contain'd in a Viol, I found that the Upper Surface of the Oyl, as well as that of the Water was Concave; tho' the Lower Superficies of it was very Protuberant and Convex; and when it had been remov'd for some time into a Cold place, so that the Oyl might be Coagulated, the Convex Superficies of the Oyl was something less protuberant: So that it seem'd to resemble a *Concavo-Convex-Glass* made use of for *Dioptrical* Purposes.

E X P E R I M E N T XV.

It is not only observable in the former Liquor, that the Oyl caus'd a much more vivid Reflection, in a Fluid than Consistent Form; but it may be further noted, That even the Shining Reflection of *Quick-silver*, may be increas'd by the Addition of a Liquor: For if Distill'd *Mercury* be put into a Viol, and *Petroleum* be gently pour'd upon it, the Reflection will be sensibly increas'd by the Addition of that Liquor; but whether that Reflection proceeds from some Subtle Body included betwixt the *Petroleum* and the *Mercury*, I shall not determine; only to make it probable, That were there

there such a Body included it might much contribute to such a *Phenomenon*, I shall add, That I once saw a Transparent Body, which was suppos'd to have a true *Oriental Pearl* in it; but upon the Breaking of it, that which was suppos'd to be a *Pearl*, was nothing but a Cavity containing a Substance, something grosser than Air: And I have a piece of Glafs by me, which hath Air included in a Cavity of a Pear-like shape, which causes such a vivid Reflection, as to resemble a fair *Pearl*. And I am Master of a Small Stone, which look'd upon in one's Hand directly down, seems to be like Common Glafs; but if the Beams of Light in another Posture fall upon it obliquely, it appears to be a fine *Opal*, or *Oriental Pearl*.

EXPERIMENT XVI.

*The Experiment in
Vacuo Boy.
Hano.*

Having melted a Gummy Substance in a deep round wide-mouth'd Glafs, and convey'd it into our *Pneumatical Receiver*; upon extracting the Air, we found, that which was contain'd in the Pores of the Gummy Substance, to rise in Bubbles, several of which settled at the Top, and others were detain'd in the Body of it, upon the Cooling of that Substance: Where it was to be observ'd, that those which were included in the Gummy Substance, did not only cause a considerable Reflection, but also the Air was so rarify'd in them, that upon the introduction of external Air into the Receiver, those Bubbles, which were rais'd to the Top, and adorned with Curious Colours, like those of a Rainbow, were presently broke.

EXPE-

EXPERIMENTS XVII, and XVIII.

Tho' it is usually thought, That the Parts of ^{Of Water} Water are Spherical, in falling Rain; yet since ^{included in} Oyl Hail, which is nothing but Drops of Water froze; and often of a Figure different from Orbicular; to be further satisfy'd concerning their Figures, we convey'd several Portions of Water into Oyl of *Cloves*, and found, that one which was as big as a Pea, was so near an Orbicular Figure, as to approach an *Elliptical* one; and other Portions of Water, which were larger, were somewhat *Elliptical*, but rather more depress'd in the middle; and these *Phænomena* were afforded by those Portions of Water which were only contiguous to the Oyl and Air.

EXPERIMENT XIX.

Having put Oyl of *Turpentine* upon Oyl of *Cloves*, which was contain'd in a Glass Cylinder; I observ'd, that Water being encompass'd betwixt these two Heterogeneous Bodies, the Surface of the Oyl of *Cloves* was but a very little protuberant; And the lower Surface of the Oyl of *Turpentine*, was but moderately Convex.

EXPERIMENT XX.

To try whether *Fluid Bodies* would retain ^{Of Coagulated Oyl of} their smooth Surfaces, when reduc'd to a Solid ^{Aniseeds.} Form, I left Oyl of *Aniseeds* to coagulate upon Water, and found that that Superficies, which was Contiguous to the Air, as well as that which was next the Water, had each a peculiar kind of Roughness.

E X P E R I M E N T XXI.

Having expos'd one Portion of Water to be froze, with Oyl of *Junipers* upon it, and another with Oyl of *Turpentine*; I found that the Ice, which was under each, had a different and peculiar Surface: A Variety of Surfaces may likewise be observ'd upon several frozen Liquors, which abound with Water. And I have observ'd my self, in a red Decoction of *Soot* of *Wood*, set to freeze, *Crystals* shap'd like Daggers, curiously emboss'd, as well as fring'd at the ends.

E X P E R I M E N T XXII.

And besides the Irregular Surfaces of a frozen Liquor, contiguous to a Heterogenous Body, I have observ'd in Oyl of *Vitriol*, that Part of it being froze, the Superficies, which was contiguous to the Liquid Part, was very unequal with several Asperities.

E X P E R I M E N T XXIII.

And not only Bodies, which are Naturally Fluid, but those brought to Fusion by *Art*, acquire Various Surfaces upon their putting on of a Solid Form; For I have observ'd, upon the Surface of a *Regulus Martis Stellatus*, and a *Regulus of Antimony* without *Mars*, Curious Embossments of the Figure of a Star; but if to these Bodies *Copper* be Artificially added, they acquire New Surfaces, sometimes resembling a Net: And I have now by me, a Mass of a Conical Figure,

Figure, consisting of two Parts, contiguous to each other, which when separated, the lower Part had upon it's upper Side, a great many Protuberances; and the Conical Part on it's Superficies, which was contiguous to that, was furnish'd with Cavities answerable to, and adapted to receive those Protuberances: Whence it might be inferr'd, That the more Metalline Part, which was emboss'd with those Protuberances, was first hardned, and the other more scoriuous and recrementitious Part, was afterwards adapted in it's Coagulation to the Protuberances of that which would melt with the Heat of one's Hand, tho' the Metalline Ingredients be much more hard to be brought to Fusion than Lead, or even Silver it self; and we have sometimes obtain'd such a Vitriol, as might be preserv'd in a fluid Form by the languid Heat of the Sun in Winter, either with Spirit of Nitre or a certain *Aqua fortis*: From whence it appears, that the Textures of Compositions are to be consider'd, as well as the particular Consistence of the Ingredients.

CHAP. XIII.

Containing the History of Firmness.

ALTHO' the Compactness and Solidity of Bodies, is usually attributed to the Coagulating Qualities of a saline Ingredient, by the Chymists, yet since their Explications are

not intelligible, I shall proceed to enquire after another Cause. *First* then

A Definition of Solidity.

The Solidity of a Body being a Quality contrary to Fluidity, seems to consist in this, *viz.* That the gross Parts of solid Bodies are so entangled and interwoven together, that they are unapt to diffuse themselves several ways, like fluid Bodies; and that the Figure of their Superficies is rather to be attributed to the Connection of the Parts that compose them, than to the Impressions of outward Bodies. In which Definition these three Things appear to be the Causes of Solidity, *viz.* Grossness of Parts, Rest, and the Implication of the constituent Parts.

The Grossness of the Parts of a Body contributes to its Solidity.

And *First*, That the Grossness of the Parts of a Body contributes to the Solidity of it, is evident from what hath been already said of Fluidity; for if Minuteness of Parts is requisite to produce such a Quality as Fluidity, it must follow that the Inaptitude that is in grosser Matter to be put in Motion must be a further Argument, That the Grossness of Particles is conducive to Firmness.

But here it is to be noted, that by Grossness or Minuteness of Parts, I would not pretend to decide the Controversy, Whether Bodies may be indefinitely divided into smaller Parts; but I would only intimate, that tho' mentally all Bodies may have an indefinite Divisibility, yet the Parts of solid Bodies are made up of a Number of such minute Parts, as convening together form those grosser Corpuscles, which, when united, are not to be dissolved by the external Impressions of ambient Air or *Aether*, or any thing

thing else, usually reckon'd amongst the Causes of *Fluidity*.

Secondly, It is to be noted, That tho' I have said, that the Grossness of Bodies contributes to their *Firmness*, yet I would be understood to mean, *ceteris paribus*; for the gross Parts of a Body, by being broke and divided into smaller, may be so dispos'd, to lye nearer one another, so as upon their more close Union, to put on the Nature of *Firmness* more conspicuously, by affording a more full Contact to other Bodies, especially, if those minuter Parts be so adapted, as to leave smaller Pores betwixt them. But this being evident from what hath gone before, I shall pass on to

The other Requisite for the producing of solid Bodies, viz. *Rest*, which, tho' it is taken notice of by the Ingenious *Des Cartes*, yet since it is not confirm'd by Experimental Philosophy, I shall here illustrate it a little further; first observing, that it is agreed on to be one of the Laws of Motion, That when a Body is at rest it will continue to be so, till forc'd to move by the Impulse of an outward Agent; and whatever may be urg'd by some Atomists, concerning the Adhesion of the minute Parts of Matter, yet, that a Juxta-position of Parts is sufficient, without the Addition of a Cement, is evident; since several Pieces of Glass, if exactly fitted and polished, will adhere so firmly together, that by lifting up the uppermost, the rest will adhere so closely as to be rais'd with them; which will also succeed, if two Marbles exactly polished and ground, have their Superficies apply'd to one another; and it is further remarkable,

Rest contributes to the Solidity of Bodies.

able, that if two Glasses be rubb'd one against another, the one will be suspended at the other, without any visible Prop to support it, and preserve it from falling. But here it may be necessary to take notice, that an exact and level Superficies is not always requisite to make the Experiment succeed, since a concave and a convex Glass rightly adapted will adhere with the same degree of Cohesion; an Example of which we have had in a Glass Stopple, duly adapted to the neck of a Bottle, by which the Bottle, containing a Pound weight of Liquor, might several times be lifted up from the Table; which could proceed from nothing, but the close contact of those two Bodies; unless it be urg'd, that by pressing the Stopple down the small Asperities of the one might be squeez'd into the small Pores of the other.

*A Juxta-
position of
Parts, not
the only
Cause of
their Adhe-
sion.*

But tho' from hence it may be argu'd, that a bare Juxta-position is sufficient to account for the Cohesion of the Parts of some Bodies, yet it is not to be deny'd, but that their strict Contact may be promoted by the Spring and Pressure of the *Atmo-sphere*; since by reason of their Juxta-position, the Air, which presses upon the lower Superficies, hath not an equal Pressure to balance it on the other Side of the same Piece; it being immediately contiguous to the lower Superficies of the Piece adjoyn'd to it; by which Means the Pressure of the Air resisting the Gravity of the Glass, instead of tending towards the Centre it is boy'd up and press'd against the upper Piece, just as if a Board were press'd with ones Hand against the Ceiling of a Room, which will continue in that Place as long as the Pressure with
ones

ones hand is continu'd : And indeed, That the Air does so press upon the lower Superficies of Glas is but the natural Effect of the Weight and Spring of it, which being bent and press'd together, by the Weight of incumbent Air, will naturally recoil and fly back, from the Superficies of the Earth, upon any Body which is in the Way to be press'd upon.

To confirm this Conjecture I shall add, that if a Piece of Glas be stuck to the Superficies of a Looking-glas parallel to the Horizon, it will stick fast to it, except it be mov'd by one Hand ; but if the Horizontal Superficies be inclin'd, the smaller Glas will readily slip from one Side of the greater to the other, accordingly as it is differently inclin'd. The Reason of which is, partly because the Gravity of it does not resist the Horizontal Motion, but only that which tends from the Centre ; and partly, or chiefly, because the Pressure of the Air on both Edges of the Glas is equal, and consequently its own Gravity makes it tend either this or that way, as the Glas is variously erected or inclin'd ; whereas the Superficies adhering to the Looking-glas receives no Pressure proportionable to the Pressure of Air recoyling against the lower Surface. And for a like reason, if the neck of a glas Viol full of Mercury be immers'd in fluid Quick-silver, the Bottle will continue near full, as long as the neck of the Glas is immers'd in the Quick-silver, tho' it be several ways inclin'd ; the Reason of which seems to be, only the Pressure of the external Air upon the Surface of the Mercury ; by which Means it is forc'd up against the Surface of the inverted Glas, so

*The Weight
and Spring
of the Air
may contri-
bute to the
Cohesion of
Parts.*

that for want of an equivalent Pressure upon the Mercury in the Glass it is kept from subsiding; for that it does not proceed from Nature's Abhorrency of a *Vacuum* is plain, from what hath been try'd concerning the suspended Mercury in the *Torrecellian* Experiment; and that it may appear more fully, that the Exclusion of Air, as well as its immediate Contact, contributes to the keeping of Bodies from falling asunder, it will suffice to relate, that having suck'd a good Quantity of Air out of a Bottle, and apply'd a Book which was next at hand to the Orifice, it stuck so firmly to it, that, tho' the Weight of it was 20 Ounces, it would be rais'd a considerable Height, and tho' but a small Part of its Superficies adher'd to the circular Edges of the Glass. The Reason of which seems to be no other, than that the Pressure of the external Air overpowers the weak Resistence made by the Air in the Bottle; and since the Resistence of the internal Air is so weak, the whole Orifice of the Bottle seems in some Measure to be a common Superficies; for as much as the Pressure of the Air in the Bottle, scarce makes any sensible Impulse upon that Part of the Book encircled by the Edges of it.

*The Solidi-
ty of Glass
depends on
a Juxta-po-
sition of
Parts.*

And it is not altogether improbable, but that the compact Texture of Glass, may depend on a like Juxta-position of Parts, since the Particles of Fire, in the making of it, may so divide the Parts of the Ingredients as to render them subtil enough for so strict and close a Union, as is requisite to exclude Air from betwixt them; for it is not only obvious, That Air cannot penetrate the Pores of it, when heated

in

in Distillation, but in blowing of Glasses where it hath not the least Vent; through the Pores of it, tho' impell'd with Force, yet its Pores are fine enough to give way to the Beams of Light and Heat, and likewise to the fine Effluvia of a Loadstone, without damaging the Texture of it in the least; nor would it be more absurd to conceive that the Parts of Salt-petre or Ice were after the like manner joyn'd together, by a Juxta-position.

But to return to the Place from whence we have made this short Digression; tho' from hence it appears, that the Spring of the Air may contribute to the Cohesion of the Parts of Solids; yet it is not altogether necessary, since the same may be accounted for by the Air consider'd barely as a Weight; for the Air being a fluid Body, and pressing by its Gravity towards the Centre, it must needs diffuse it self every way, when resisted by the Surface of the Earth, and consequently expand it self orbicularly, by which means the whole Pillar of Air incumbent on it, being virtually incumbent on the lower Superficies of the Glass, whatever separates one from the other, must out-balance that Pressure of the Air; otherwise (there being no Air betwixt the two Glasses) they must needs stick together; but it is not necessary that the contiguous Superficies of these two Glasses should be equal to the Horizon, since if they be perpendicular, the Sides of the Glasses have a collateral Pressure from the Pillars of Air pressing against them, and consequently the Difficulty must be as great to separate them.

But

But to try more exactly, How much the Pressure of the Air is concern'd in the former Experiments, we took two polish'd Marbles, as smooth as we could get, and fastned Wires to the uppermost, so that the lowest could not slide off the other Horizontally, but, if any way, must fall Perpendicularly; which Caution being observ'd, we found, the one would not only draw up the other, but a Pair of Scales fixed to it with 16 Ounces of *Troy* Weight; and to make the Experiment more compleat we found, That when the Surfaces of the Stones were wet with pure Spirit of Wine, the Air being by that Means kept from insinuating it self betwixt the Stones, the uppermost would not only draw up the other with a pair of Scales, but an hundred, and sometimes a hundred and thirty Ounces of *Troy* Weight; tho' the Diameter of the Stones exceeded not an Inch and two Thirds: But having repeated the Experiment with Oyl of sweet Almonds instead of Spirit of Wine, we found, that it took up above four hundred Ounces *Troy* Weight: And that it may not be suspected, That this Difference proceeds from the more clammy Parts of the Oyl, which caus'd the Stones to adhere more closely, I shall add, That the contiguous Surfaces being held perpendicular, tho' they would easily slide off each other, when moisten'd with Oyl, yet would they not slip down, when moistned with Spirit of Wine, without an additional Weight joyn'd to one of them, the Protuberances of one, perhaps, being fastned in the Pores of the other.

But

But to shew, That the Adhesion of these polish'd Marbles is proportionably greater as the Diameter of them is larger, and consequently as they are press'd together by a larger Pillar of Air, I repeated the same Experiment with Spirit of Wine, and took up about four hundred and seventy Ounces; but when I made use of Oyl of Almonds, the Weight rais'd, was much more considerable, being a Thousand three hundred and forty four Ounces of *Troy* Weight; besides at the same time the Marbles were observ'd to stick close together: And here again, lest it should be suspected, that the Oyl made the Adhesion more close, I shall relate this Observation, *viz.* That tho' It requir'd so great a Weight to separate these Stones when their contiguous Surfaces were in an Horizontal Line; yet would they easily slide one upon another, not unlike the contiguous Glasses before mention'd; and for the same Reasons; and if they were the least inclin'd either this way or that, their own Weight was sufficient to separate them: From whence it appears how much the Air may be concern'd in compressing the Particles of solid Bodies together.

And lest it should be further objected, That the Cohesion of these Stones rather proceeds from Nature's Abhorrency of a *Vacuum*, than the Cause assign'd by us, I shall add these Considerations; *First*, That if it were so, the same Reason would hold when a much more considerable Weight is fastned to the lower Marble; yet we see, that then, notwithstanding Nature's Abhorrency of a *Vacuum*, they presently part. *Secondly*, That the Pressure of the Air is sufficient

cient to account for it : Which to make it more plausible I shall add, that tho' the Stone were fastned to the Ground, yet it would require as much Force, to separate the Uppermost from it in a Perpendicular Line, as to lift up a weight æquiponderant with the Stone, and the Pillar of Air incumbent on it, since there is neither Air, nor any other Body, betwixt the two Stones to help to raise the Lower up, and in part to sustain the weight of the incumbent *Atmosphere*; and therefore it needs not seem strange, that when the lower Marble and the weight affixed to it, is not sufficient to ballance the weight of the *Atmosphere*, it should rise along with the Uppermost when drawn up, rather than be separated from it; since it is usual, for two Bodies, when joyned together, to move the same way, if they be not separated by Weights or some other Force; which is observable in trying of *Load-stones*; for if the *Load-stone* be able to raise a Body more ponderous than it self, the Knife will as soon raise the *Load-stone* as the *Load-stone* will lift up the Knife.

To Illustrate what hath been said I shall add an *Experiment* registred amongst my *Adversaria*, which is this, viz. Having immersed a Glasse *Syphon* with a Brass Valve cemented on one end, almost half a Yard in a tall Cucurbite, till it touched the Bottom, I filled it with Water, till the Superficies of the Water in it, was equal to that in the Cucurbite, which being done, I took a pair of Scales, putting an Ounce weight into one Scale, and fixing a String to the other, one end of the String being likewise fastned to the Valve, fixed to the bottom of the

the Glass Tube ; where it was to be observed, that by that single Ounce I was able to open the Valve, whereas when the Water was poured out of the Pipe, and it was immersed again, the Valve would not be open'd again without the Additional weight of four Ounces ; And in this *Experiment* it was further to be observed, that as the Valve was raised higher and higher in the Cucurbite, a weight portionably less was sufficient to open it. In which *Experiment*, if *suga Vacui* resisted the opening of the Valve, it would have required the same weight at the top of the Water as in the Bottom, the Valve being in both places under Water. And therefore the difference rather proceeds from the Compressure of the Ambient Water, that presses the Parts of the Valve together. And tho' Air be a Body much more light than Water, yet considering that the difference is but about as much as 1000 to 1, and that the Particles of Air, which press upon our *Atmosphere*, are incumbent upon each other for several score Miles in height ; it is not absurd to expect, that their pressure should be considerable, and sufficient to press the two Marbles together.

For a further Confirmation of our Doctrine of Firmness, to this I shall add another *Experiment*, which is, that having suspended the aforementioned coherent Marbles in a large Glass, when the Air was considerably exhausted the lower presently fell from it ; And tho' the uppermost was let down to it, yet it could not be raised, till fresh Air was admitted into the Glass again, and then they were again pressed strongly

strongly together and became coherent as in the open Air.

*Rest it self
for the most
part suffici-
ent to cause
Rest.*

But to return to our Discourse from which these *Experiments* have made a Digression; tho' the Pressure of the Air may so joyn Bodies together, as to make them coherent; yet generally, Rest it self is sufficient to render a substance Solid; for since from what we have said above, concerning *Fluidity*, it appears, that it depends on the Motion of Minute Parts one amongst another; to deprive Matter of that Motion is enough to render it Solid, the Parts of a Solid being contiguous and at rest.

*The Opini-
ons of some
Antients
and M.
dems brief-
ly refused.*

I know it is by all *Philosophers*, whether Modern or Antient, usually held, that there is something else requisite to keep the Parts of a stable Body together: For some hold, that a Substantial Form is requisite; but since it is equally as difficult to conceive, how Matter should be so variously united in several Substances, by a substantial Form as without it, we may as well fly to imaginary Substances which are united by their peculiar Texture.

Others think, that the Particles of solid Bodies are linked together by a Spirit diffused throughout the World, or by a certain sort of Glue, which Glews their small Corpuscles together. But as to the first its altogether unlikely; for it may as well be a Question how those Parts stick to the Spirit, as how they stick to one another themselves; and it will be no less difficult to conceive, how the Particles of that Spirit it self come to be fastned together. Besides, were that true, it would follow, that Ice, which is looked upon as a Body void of Spirit, must

must abound with it; since the Parts of that brittle Substance, could not be joyned by a Spirit which was not betwixt them: Nor is it more Reasonable to suppose them joyned by a Cement, since it might likewise be asked, how the Parts of that Cement were linked together, which should it be affirmed to be done by a Substance yet finer, the Question might still be continued *ad Infinitum*; so that, it would at last be allowed, that some Parts of Matter must adhere without a Cement, or there must be Cements finer one than another *ad Infinitum*; which since it cannot be allowed, we may as well suppose, that the Parts of a Body adhere without a gross Cement, as that the Parts of a subtile Cement can stick together without another Substance to Cement them; especially, since the Corpuscles of a Body may be so figured and contrived as to be linked amongst one another very firmly; an agreeable Contact, with a real rest of Parts, contributing to render the united Substances a Solid Body.

But in favour of the former Opinion, it is urged by some, that the Spirit which they suppose joyns the Parts of a Body together, consists of Parts indivisible; and consequently, there is no need of another substance to Unite them: But since Bodies as Solid and Adamantine as these can be supposed to be may be broke, a bare Affirmation must not be taken for Proof; for to suppose, that these Parts of Matter were made up of hooked Parts; it would be as reasonable to believe, that those hooked Parts might not be broke, as that by a violent Agent the Particles of the most Solid Bodies cannot be divided, since it is plain they may. But

But to proceed, The last thing we supposed necessary to constitute a Body, was the Texture of its Parts; and indeed tho' a *Juxta-position* and *Rest* of the Parts of a Body, are sufficient to render it Solid; yet if those Parts are more intimately interwoven with one another, so as to be linked together like Hooks, it must contribute to render the Body much more firm, Parts so joyned, being much more difficultly separated, and put into Motion, than those which have only an immediate Contact; And it may not a little serve to confirm our Opinion, to take Notice, that in an Egg or Water, by a meer alteration of Texture, the Disposition of Corpuscles of those Substances are considerably changed; as when an Egg is, by the insinuation of the Parts of Fire, so altered, as to become hard; or as when the Latter as well as Water is beaten into a Froth, which in some Measure is like a Solid Body, as long as they continue in that Form.

Having thus far inquired into the conjunct Causes of Solidity, we shall consider briefly, how many Ways a Body may come to be so Modified, and what things are requisite to make Bodies apt to put on such a Form.

*This Figure
of the Parts
of a Body
contribute
to their So-
lidity.*

The first and most remarkable thing is the Figure and Shape of the Parts of Matter, as if they be hooked or otherwise shaped, so as to entangle one within another, they will be with more difficulty separated; which is evident in close-set Hedges, where by pulling away one Bough the slender Twigs of others interwoven with it, make it harder to be separated; and not

with

without pulling some others along with it ; so likewise the slender Threads, which make up Cables, being twisted and wound one within another, are capable of sustaining a much greater Weight, and require much more Force, to bracke them. And indeed this Configuration of Parts seems to have been the Opinion of the antient Atomists, of which *Lucretius* hath given the following Account in these Verses ;

*Denique quæ nobis durata ac spissa videntur,
Hæc magis hamatis inter se esse neceſs' eſt,
Et quaſi ramosis alta compacta teneri.
In quo jam genere imprimis adamantina Saxa;
Prima acie conſtant, ictuſ contemnere ſueta
Et validi ſalices, ac duri robora ferri;
Æraqûe quæ Clauſtris reſtantia vociferantur:*

And indeed the correspondent Figurés of Bodies may be ſo numerous, that the ſame Particles, which before in two diſtinct Bodies were Liquid, may, by an Union, have their Parts ſo interwoven with one another, as to become Solid ; an Inſtance of which hath been given in the foregoing Chapter concerning *Salt-Petre*, where by a Mixture of a Liquor diſtilled from *Nitre*, with a Mixture of fixed *Nitre* run *per Deliquium*, a third Subſtance will be obtain'd firm and brittle, *viz.* a Saline Body. To this I ſhall add another, mentioned with a different deſign by *Lully* and *Hartman*, which is the following, *viz.* If two Parts of rectified Spirit of Wine, be mixed with one of Spirit of Urine exquisitely Dephlegmed, they will in a Minute ~~take~~ into a conſiſtent Body ; but in this Experiment

ment it is to be Noted, that the Spirits must be more rectified than those usually made use of by the generality of *Chymists*; and I shall further observe, that having my self had the Curiosity to try it, I found that Spirit of *Harts-horn* well rectified would have the same Effects, if made use of instead of Spirit of fermented *Urine*. And it may be fit yet further to observe that tho' there was such a predisposition in the Parts of fermented *Urine* to Coagulate with Spirit of *Wine*, yet the highest Spirit of unfermented *Urine* being of a different *Texture* would not Coagulate as the former. And it is further to be noted, that if this white Coagulum was kept in a Glass well stopped for some Months, by the means of Heat it would be Melted into a limpid Liquor; those Parts of the Liquor which were intangled one within another being broke and dissolved, so that the Particles of the united Liquors being again restored to such Figures as would enable them to move upon one another's Surfaces, the *Coagulum* assumed the Form of a *Fluid Body*.

To this I shall subjoyn two *Experiments* which seem to have an Affinity with the former; the first is, That rectified Spirit of *Wine*, by being digested with *Saccharum Saturni* prepared with Spirit of *Vinegar*, so far changed its consistency as to remain in a Glass without floating as a Liquid when the Glass was inclin'd; the Second is, That by the Addition of a dry Body, from whence nothing could be obtain'd by the help of the Fire, to the Coagulum just now mention'd, the result of this Mixture was a permanent Liquor.

But for as much as the fore-mention'd Experiment

ment which produc'd the Coagulum upon the Mixture of Spirit of Wine and Urine is difficult to be performed, since it is a hard Matter to obtain Spirits fine enough for such a purpose, I shall subjoyn a more easy one, which is, That if Spirit of Salt be added to the White of an Egg beaten to a certain Thinness, the Mixture will be so much Coagulated as not to afford the least Drop, tho' the Glass in which the *Experiment* is tryed, be turn'd with the Mouth downwards for a considerable time. And Sir *Francis Bacon* relates an *Experiment* much to the same purpose; which is, That if the White of an Egg be shaken with Spirit of Wine it presently turns into such a Coagulum as will not yield one Fluid Drop in a Minutes time, and tho' that great Naturalist attributes the Effect of this Mixture, to the Heat of the Spirituous Parts; yet I rather think it the Effect of the particular *Texture* of its *Saline* Parts, since other Salts which are accounted cool, have the same Effect; And not only so but tho' Spirit of Wine will Coagulate the Whites of Eggs, yet it hath not that Effect upon the *Serum* of Mans Blood, tho' the Heat of the Fire will Coagulate the one as well as the other.

But it does not only experimentally appear, that a consistent Body may result from a Mixture of two *Fluids*; but also that a *Fluid* may undergo such an Alteration as to be changed into two Consistent Bodies; and this is evident in distilled Sallet Oyl, since the Substance drawn over is devoid of *Fluidity* as well as that which remains behind; and to make it appear, that the Reason of it is the bare result of *Texture* and the hooked Figures of its Parts, if we add to

the Oyl a sufficient Quantity of Common Salt, it affords an Oyl, which falls in drops into the Receiver, and retains its *Fluidity*. And to this it may be added, That by adding two pound of *Brandy*, and one of *Sea-Salt* to eight Ounces of Oyl of *Amber*, the Texture of that Oyl was so far from being so chang'd, as to come over clear and transparent; as Essential Oyls drawn off in *Limbecks*, usually do. To which we may likewise add, That the Texture of Oyl of *Aniseeds*, distill'd in a *Limbeck* and *Refrigeratory*, with a sufficient Quantity of Water; will, by the *Winter's* Cold, be coagulated into a white brittle Substance, tho' it continues Fluid all the *Summer*.

The Texture of Bodies contributes to their Fluidity, or Firmness.

And to make it further appear, how much the Alteration of Texture contributes to the *Fluidity*, or *Firmness* of Bodies; and to what weak, and almost inconsiderable Agents, those Effects may be attributed; I shall subjoyn another Experiment, which shews, that the Particles of a Body may be sufficiently agitated, to render it Fluid, by another not sensibly hot; for having melted coagulated Oyl of *Aniseeds* by the Fire, and put it into two Glasses; the one was coagulated again in a short time; yet the other continu'd dissolv'd, being only cover'd over with a *Menstruum*, in whose Parts there is no sensible Heat.

To this I shall add another, of a much like Nature, which is the following. Having powder'd some of that brittle Gum or *Colophony*, which remains upon the Evaporation of about a fourth Part of *Venice Turpentine*, I mix'd so much of it with Spirit of Wine, that, the Liquor being wholly impregnated with it, some part might remain undissolv'd; which never-

theless

theless had its Parts put into an Agitation, sufficient to render it, in some measure, a Fluid, tho' a Viscous Substance, notwithstanding the Force of the *Menstruum* was spent upon what had been dissolv'd; but tho' this Substance was kept in a Fluid Form in the *Menstruum*; yet in the Air, it would harden in a little time. And in this *Experiment*, it is likewise observable, That tho', by a violent Agitation, the Viscid Matter was mix'd with the *Menstruum*, yet it presently separated, and subsided again.

And this suggests to my Memory an *Experiment*, which shews how much the Textures of Liquors contribute to their Mixtures with each other; for tho' it be usually in General asserted by the *Chymists*, That *Salts* and *Oyls* will not mix together; yet I obtain'd an *Opacous* Liquor, like *Balsam* in Consistence, from a Mixture of an equal weight of Oyl of *Turpentine*, and Oyl of *Virriol*: And that it might more evidently appear, that the Mixture of these two Fluids, depends on the peculiar Texture of each, I committed the Mixture to Distillation; and obtain'd a gross Substance, which seem'd to be that which united the other Liquors: For as soon as this was drawn off, the Liquors presently succeeded, but separate one from another, being not to be united again, by a Violent Agitation, but so as to separate again, and swim one upon another. To this may be added the Liquor, which we have mention'd in another place, obtain'd by Distillation from *Benzoin*: One Part of it always continuing in the Form of an Oyl; and the other, according to the Difference of the Weather, either shooting into clear *Crytals*, or preserving its

The Textures of Liquors contribute to their Mixture.

it's Fluid and Oyly Form. To which may be subjoyn'd what we have formely taken Notice of concerning *Salt-Petre*; which, tho' when mix'd with Water, it becomes Fluid; yet, upon an Evaporation of some Part of that, it presently shoots in Solid *Chrystals*: From whence it not only appears, what a gentle Agitation of Parts is sufficient to keep a Body Fluid; but from hence we may observe, That sometimes Solid Bodies result from a Mixture of Liquids: So Oyl of *Vitriol*, distill'd with *Quick-silver*, leaves a white *Calx* behind it; and if we consider how *Mercurium Dulcis* is prepar'd, we shall find, that that Solid Substance consists for the most part of *Quick-silver*, the *Salts* united with it being scarce one Part of three of the Composition. And tho' *Fluidity* be opposit to *Solidity*, yet may it conduce to the Production of a Solid Body, since those Particles which lie in the Form of a Powder, and are not in a capacity to unite, may, by swimming in a Fluid, have the Opportunity of frequent Occursions, so that their Motion bringing them often together, they may, in time, be dispos'd to unite into one Body; which is evident in Powder of *Alabaster*; which, if when it hath been boyl'd for a considerable time, it be well burnt, and reduc'd to the Consistence of a thin Pap, with clear Water, will become firm, and admit of, as well as retain, any Form impress'd upon it, by the Internal Surface of whatever Mould it is cast in: Where, that the Parts of the *Alabaster* are put into Motion, and variously agitated in the Water, is evident, from that sensible Heat, which for some time, succeeds the Affusion of Water; and this hath been
suffi-

ufficiently experienc'd, by filling a Glass full of this Mixture, which some time after it was stopp'd, broke the Viol, and harden'd into a Substance, correspondent in shape to the Cavity of it; several Spoons-full of this Liquor it was moisten'd with, being squeez'd out at a Crack, which was made by the Swelling of the Powder; and this Substance acquires such a Degree of Firmness, as to endure several strokes with a strong piece of *Iron*, without breaking.

But there are several other Substances, which may acquire a greater degree of Solidity, than the Powder of *Alabaster* burnt; for the Learned *Hydrographer Furner*, *Hydrograph. lib. 2. cap. 6.* relates a Story of a sort of Sand in the Kingdom of *Naples*, near *Cuma* and *Puteoli*, two parts of, which mix'd with a third of *Quick-lime*, becomes a hard Substance like *Flint*, when it hath lain or some time in the Water: To which Relation he subjoyns, That the *Lime-ashes* of a certain *Marble*, near *Tournay* in *Holland*, being cast into Water, upon a heap of Stones, petrifies to that degree, as to change into a Substance as hard as *Marble*.

But to return to what we have digress'd from, That the Various determin'd Motions of the Parts of Matter, contributes to their Union and Coalitions, into Solid Substances, appears from those Curious *Salts*, which Spontaneously shoot and *Crystallize* in the Bottom of Spirit of *Harts-Horn*, when it hath been expos'd to the Air for several Months: For those Particles, by frequent Occursions, are by degrees so dispos'd to unite, that at the length those Parts, which

are most apt to cohere, meeting together, they form exquisitely figur'd *Crystals*, which adhere to the sides of the Vessel. And it is not less Remarkable, That tho' a Tincture of *Amber*, drawn with pure Spirit of *Wine*, for some Years continu'd Fluid; yet, at the last, some of its Parts were so combin'd, as to form little Parcels of *Amber*, almost Spherical in Shape, which adhered partly to the Sides, and partly to the Bottom of the Vessel.

Solidity
may proceed
from the In-
terposition
of the Mi-
nute Parts
of another
Body.

But there are yet other ways, by which Bodies may become Compact and Solid, as first by the Insinuation of Small Particles of Matter, into their Pores and Recelles; which may produce their Effects various ways: First, by driving out those Particles, which being dispos'd to Motion, hinder'd the Cohesion of the Fluid Parts. Secondly, by obstructing the Motion of the Fluid Parts: And, Thirdly, by altering the Constituent Parts of the Fluid, so as to render them unapt for Motion, and inclinable to a mutual cohesion: So the Particles which constitute *Rennet*, by Uniting with some Parts of the *Milk* they are mix'd with, link them together, and cause them to unite into a *Coagulum*; and that the Parts of the *Rennet* cause them to coagulate; and that they unite those Viscid Parts, and link them together, is plain; since it is a usual Complaint that the *Cheese* made where *Rennet* is us'd, tastes very strong of it. And that the Coagulating Virtue depends on the Saline Parts of the *Rennet*, appears; since other Acid Liquors have the like Effect in Coagulating *Milk*, as Juice of *Lemons*, &c. as also a very small Quantity of Oyl of *Vitriol*, artificially mix'd with it.

it. To which I shall add, That some Years past, I prepar'd a certain *Salt*, endew'd with Qualities not unlike those ascrib'd to *Glauber's Sal Mirabilis*; which would not only, like other *Salts*, when dissolv'd in *Water*, upon Evaporation, shoot into *Crystals*, it self; but also would coagulate, and *Crystallize* a treble Quantity of *Water* with them, which would so far put on the Nature of a *Salt*, as to become brittle, and to be reducible to Powder.

And it may not be fruitless here to subjoyn, That tho' the Particles of Oyl of *Vitriol*, be in so violent an Agitation, as to acquire a Sensible Heat, upon their Mixture with some Bodies; yet I so alter'd the Texture of that Liquor, as, by a Mixture of a certain whitish Powder of my own Preparation, to render it a Consistent Body: In which *Experiment*, it was observable, That several Days, after the Oyl was coagulated, the Powder remain'd undissolv'd in the Bottom of the Viol; so that the Coagulation seem'd to be effected by some subtile *Effluvia*, insinuating themselves into the Pores of the Liquor. To this *Experiment*, I shall subjoyn another, in which the same Effect was produc'd, by leaving Oyl of *Vitriol* upon *Crystals* of *Salt-Petre* well dry'd; where it was to be noted, That the Oyl was not only Coagulated, but seem'd to be joyn'd together, by certain Fibres, which were form'd out of the Saline *Effluvia* of the *Salt-Petre*, dispers'd through the Body of the Oyl. And that those subtile *Effluvia*, which insinuate themselves into the Pores of a Fluid Body, may so alter the Texture, as to render it Solid, is more eminently evident, from the Fumes of
Lead,

Lead, which Coagulate and harden, *Quick-silver*; and that *Lead*, does really emit such Fumes, is evident, from the Effects which a *Physician* observ'd in himself; viz. both *Vomiting* and *Purging*, by barely holding his Head over melted *Lead*, several times successively. and it hath been observ'd by the Famous *Geometrician* Dr. *Wallis*, That the Fumes of *Lead*, have, by being several times melted, been so spent, that the *Lead*, after the first time it was melted, sometimes lost it's a Coagulating Virtue. And *Phænomena* not much different from the former, are exhibited by the following Experiment: For if either Common, or Oyl of Sweet *Almonds*, be pour'd upon *Aqua fortis*, the Steams of the Latter will soon Coagulate either of them; whereas if *Camphire*, which is a brittle Substance, were cast upon the same *Aqua fortis*, it would be turn'd into an Oily Substance; which shews how much the *Effluvia* of Bodies may contribute to *Fluidity*, or *Firmness*, accordingly as the Bodies acted on, are pre-dispos'd to assume different *Forms*: And before I leave this Experiment, it may be material to take Notice, That tho' Oyl of *Tartar*, per *Deliquium*, be endew'd with an Extraordinary Faculty of Mortifying *Acids*, yet it would not reduce the Coagulated Oyl to a *Fluid Form*.

A Fluid
turn'd So-
lid.

A Solid Bo-
dy turn'd
Fluid.

But to proceed: The Last way by which such Penetrating *Effluvia* may conduce to the Solidity of Bodies, is, by putting those Bodies into such Violent Motions, as they may, by being impell'd upon, and knock'd one against another, be dispos'd to Union; and to be entagl'd one within another.

And

And tho' this Concurrent Cause, never acts separately, without the Joynt-Action of the aforementioned Ways, yet is it necessary to make a Distinction; because this differs from the Former, in as much as these *Effluvia*, contrary to the other, make up no part of the Body, upon which the Alteration is wrought, but only agitate the Parts of it: So that the *Figure* and the *Texture* of the Parts of the Body, become different from one another, and more complicated. A Complication of Parts sufficient to render a Body Solid. And that a bare Complication of Particles, is sufficient, in a great Measure, to render a Body stable, will appear from an Observation very common; viz. That tho' from a heap of *Olive-wands*, a single Twig may be taken, without removing the rest; yet if they be twisted together in the Form of a *Basket*, the whole follow upon the taking up of one; and the same may be observ'd, in most of the Works of *Mechanicks*. And what great Effects bare Motion may have, in altering the *Textures* of Bodies, is manifest, and very obvious in *Churning*; where the Branched Particles, which are dispers'd and diffus'd through the whole, by frequent Occursions, are so freed from the rest of the Liquor, that they presently unite, and form that soft Oily Substance call'd *Butter*; and not only so Homogeneous a Body as *Milk*, may be so alter'd by Motion, but even Oyl of *Turpentine*, may be render'd a Consistent Body, without the Assistance of any other Agent, than Motion given to it's Parts by *Distillation*, the Substance drawn off being a Stable and Consistent *Cogulum*. And to illustrate farther, what we have deliver'd of *Fluidity* and *Firmness*; I shall add

add the following *Experiment*; viz. That Oyl of *Wax*, being distill'd, afforded a Substance not unlike *Butter*; which when it had stood a while, was dissolv'd, without the Influence of any External Heat, into a Transparent Oyl.

*A Change
of Qualities
succeed a
Change of
Texture.*

But further: *Fluidity* and *Firmness* so much depend upon *Texture*, that the same *Corpuscles*, which united one way form a *Fluid*, by an opposite *Texture*, may become Solid, and *è conversò*: And this is not only evident, in *Water* successively Froze and Thaw'd again; but also in Metals, which, after *Fusion*, put on their Pristine Form, upon Cooling: But a more Eminent Instance is, That *Quick-silver* being kept in a Sand-Furnace, for about ten Weeks, in a Glass-Vessel well stopp'd; the Particles of that Body, being variously entangl'd and wound together, constitute a Red Powder; which may, by *Chymists*, be precipitated *per se*; and in a few Hours, if a quantity of *Quick-silver* be distill'd in a Glass Retort, a Red Powder, like the former, will remain in the Bottom, as well as about the Sides of the Vessel: In which wonderful *Phenomenon*, it is not absurd to imagine, that the Change is wrought, much after the same manner as in Whites of *Eggs*, which by an Alteration of *Textures*, become hard; or, that by frequent Revolutions, the Parts of that Liquor are so link'd one within another, as to put on a different Form; and whatever may be the Method by which this Change is effected, yet, that it depends on an Alteration of *Texture*, is most certain; since that Powder being rais'd in the Form of *Fumes*, in a convenient Glass, condens'd into Running *Mercury*, in the Neck of it.

But

But to prove further how much *Motion*, or *Rest*, contributes to the *Fluidity* or *Solidity* of Bodies, I shall add, That I once had *Mercury*, which I looked upon to be *Mercury* of *Saturn*, which by being barely agitated to and fro, would put on the Form of a Black Powder, which would again become fluid *Mercury*, by grinding it in a Glass-Mortar.

From which *Experiments* of *Mercury*, we may learn, what may be thought concerning the Opinions of some Modern *Philosophers*, who are of Opinion, That *Fluid Bodies* may be divided into *Fluid Bodies*, as *Quantity* into *Quantity*; as if every Particle of a *Fluid Body*, must be *Fluid* it self; since, from the aforementioned *Experiments*, it is evident, that the Particles which constitute *Fluids*, are *Solid* in themselves; forasmuch as, upon a bare Change of *Texture*, they appear in that Form; which is render'd further probable, if not evident, both since the Particles of which *Salt* consists, being dissolv'd in *Water*, put on, as to Sense, the Forms of *Fluids*; as well as, because the *Corpuscles* of so *Solid* a Body as *Silver*, do the same, when dissolv'd in *Aqua fortis*: And on the contrary, the *Calx*, remaining behind, after a Distillation of *Quick-silver*, with four times its quantity of *Oyl* of *Visriol*, in a Sand-Furnace, is a Consistent Substance, which, if dissolv'd in *Water*, will after Evaporation, shoot into very brittle *Crystals*; which rather proceeds from the Parts of the *Oyl* condens'd, than from those of the Metal; since the *Calx* remaining behind, exceeded the weight of the *Mercury*, the Liquor drawn off, being not equal to that of the *Oyl*. And

I am further confirm'd in this Opinion, because I have observ'd several Crystals sometimes to adhere to the Sides of a Glass, in which Oyl of Vitriol was contain'd, which were again resolv'd when expos'd to the open Air into the pristine Form of Oyl. But it may be further urg'd, as an Argument against the Divisibility of fluid Bodies into such fluid Parts, that if it were so, all Bodies would be equally dispos'd to insinuate themselves into the Pores of other Bodies; and it would not happen, that one Body should be more inclin'd than another.

Motion as well as Minuteness of Parts requisite to Fluidity.

It is not indeed to be deny'd, but that a fluid Body may be divided into very small Parts, consider'd barely as Matter; and that Minuteness of Parts may render it more apt for Motion, and consequently more fluid; but it does not therefore follow, That the Parts of a fluid Body are indefinitely so divided, because consider'd as Matter, they may be *Mentally*, since it does not appear, that they are *Naturally* so divided: Besides, to render a Body fluid, Motion as well as Minuteness of Parts is requisite, which appears from what we have said before concerning Powder of Alabaster, which puts on the Form of a fluid, by having its Parts violently agitated. But

Solidity not altogether proceeding from Saline Parts.

From what hath been already premis'd it appears likewise, What Thoughts we are to entertain of the Doctrin of the Chymists, who assert, That Coagulation, Stability, &c. are the Effects of saline Parts. For tho' Salt hath a Power to curdle Milk and coagulate other Humors; yet the hardning Properties of it are not the Effects of any inexplicable Qualities inherent

herent in it; but of the Shape and Motion of the Particles which constitute it, which, by insinuating themselves into the Pores of a Body, and sticking several Parts together, do like a Wire fasten them one to another. But notwithstanding the saline Parts of a Body may thus contribute to the Solidity of it, yet it is not an Ingredient altogether necessary; since the Parts of a Body may be so interwoven, and, by reason of their Figure and Contexture, be so dispos'd to Union, as to form a solid Body without the Association of a saline Ingredient; besides, it might be urg'd, That Salts themselves may easily be reduc'd into fluid Substances, by a Mixture of Water; and several of them, as Salt of Tartar, &c. will, without the Addition of any other Body, barely by being expos'd to the Air, be render'd fluid.

But not to insist upon these Instances, I shall rather desire to know, what Salt can be suppos'd to insinuate it self into, and cause Solidity in Mercury, when it coagulates in the Fumes of Lead? Or what Access of saline Parts can be imagin'd in the Preparation of Mercury precipitated *per se*? And it may as well be question'd, how any saline Body can penetrate the fine and subtle Pores of Glass? When, in a cold Night the Water contain'd in it is frozen, and is turn'd to so consistent a Substance as Ice. And it may be likewise noted, That tho' the Shells of Hens Eggs be soft when first lay'd, yet they presently harden without the Addition of any other saline Ingredient. And that this Effect cannot be wholly attributed to the Influence of the Air, it may be urg'd, that it hath oftentimes

times been observ'd, That Shells have been found hard several times in the very Bodies of the Hens, before they were laid.

But that which I look upon to be a more convincing Argument, is, that in *Egypt*, where Eggs are hatch'd by the Influence of a moderate external Heat, that fluid Substance is chang'd into several Parts, of very different Degrees of Consistency, without the Addition of any other Body, or the Accession of a new Salt.

But further, I shall make use of Arguments drawn from the Concessions of the most Eminent of their own Writers; for in transmuting of Quick-silver into Gold, by a white or red Tincture, the Quantity of it being only a Grain to a Pound of Quick-silver; it may justly be demanded, How so small a Quantity should change six or seven Thousand times its Weight, whereas even that Grain is not altogether saline, Part of it being a sulphureous Substance? And it is observ'd, that *Helmont* affirms upon his own, as well as the Experience of *Raymond Lully*, that if the *Alkaloſt* were drawn from Quick-silver, the fluid Mercury would be so coagulated, as to be capable of being reduc'd into a Powder, tho' not the least of the saline Liquor was left behind. And I am credibly inform'd that the present Duke of *Holstein* hath by him a certain Glas Spirit of Urine, which in cold Weather shoots into Cryſtals, and in warm dissolves into a limpid Liquor; which Spirit was no otherwise prepar'd than by cohobating the distill'd Spirit so often, till the whole saline urinous Substance was brought over united together into one Mass.

And

And for a further Confirmation of the Doctrine by us deliver'd, to these I shall add, that it hath been observ'd, that if so much as Juice of Lemmons falls into a Caldron of Sacharine Syrup, it keeps the whole Mass from Thickning into a Sugar; and this is confirm'd, both by the French Publisher of the Natural and Moral History of the *American Islands*, call'd *Les Isles Antilles* Histor. Moral. Cap. 5. and also by *Gudelmus Piso* Histor. Nat. & Med. *Brasil.* l. 4. c. 1. the latter of which expresses himself in these Words, *Si Momentum succi Limonis, vel Acidi quid injiciatur, Sacchari Consistentiam nunquam acquirat, sed in totum perditur*; and it may be further observ'd to our present Purpose, that in making of Sugar, the Juice squeez'd out of the Canes, is usually first depurated in large Vessels of Copper, from whence it is remov'd into Vessels of a less Size, in order to a farther Depuration; where we are to note also, that whilst it remains in the larger Vessels, they usually add very strong Lees to promote Depuration, and when the depurated Liquor is remov'd to the small Vessels, it is the Custom to add Oyl or Butter to preserve the Liquor, and to prevent it from boiling over, which Preparation *Piso* takes notice of, together with the above-mention'd Author, the Words of the former being these, *Observatu dignum, si Oleum majoribus inderetur Abenis, in quibus Liquor prius, Caldo dictus, purificatur, Saccharo conficendo planè foret ineptus; vicissim si minoribus lixivium sicut majoribus infundatur, aquè impossibile Saccharum conficere.* The Fluidity and Firmness of Bodies depend so much upon the peculiar

M

Texture

Texture of the Matter which constitutes them, rather than on a saline Substance.

*An insipid
Water
drawn from
Sp. of Vine-
gar & Salt
of Tartar.*

*Camphire
dissolv'd in
Oyl of Vi-
triol, &c.*

To these Authorities, for a further Confirmation of our Hypothesis, I shall add a few Experiments of my own; and first, having prepar'd a Liquor not much inferior in Saltness to *Aqua fortis*, and then put small Fragments of solid Harts-horn into it, we found, that they were gradually soften'd, the Particles of the Liquor insinuating themselves into the Pores of the consistent Body, and rendring it in a few days time of the Consistence of a Mucilage: We mix'd likewise Spirit of Vinegar with Salt of Tartar, till the Ebullition wholly ceas'd, and by Distillation obtain'd an insipid Water from the Mixture; and so successively pour'd fresh Spirit of Vinegar upon the Mixture, and again extracted the insipid Water, repeating reiterated Affusions and Distillations, till the fix'd Salt was sufficiently impregnated with the Acid Parts of the Vinegar; and then we obtain'd a Mixture, tho' made up of pure and elementary Salts, which so far emulated a fluid Body, as to depose its saline Form when influenc'd by a very moderate Heat. Again, we mix'd some Pieces of Camphire with Oyl of Vitriol, by which they were presently dissolv'd into an Oyl, and when violently agitated together, readily mix'd with the Oyl of Vitriol, and seem'd to constitute a uniform Liquor for several Hours; yet by an Addition of four times as much fair Water, the Camphire presently assum'd its own Form again, and swam upon the Top of the Liquor; where it is to be noted, That the saline Parts of the Oyl of Vitriol render the Camphire

phire Fluid, instead of making it more Solid ; and on the contrary, that Fluid is turned into a Consistent Body again, by a Body so much void of Saltiness as Water.

And that a Body may acquire those other Qualities, viz. Hardness and Brittleness, without an Addition of *Saline* Parts, is evident, from the different Tempers that may be given to a Piece of Steel ; for if it be immersed in Water red hot, it acquires a Brittleness and Hardness, which it hath not, if leisurely cooled in the Air ; yet if it be again heated till it turns to a deep Blue, it acquires a comparative softness and aptness to bend. And that an Alteration in *Texture*, is enough to render a Body more or less Solid, is evident in Snow ; for its Parts being compressed more closely together, it is abler to resist the Impressions of other Bodies ; and yet when further, by thawing it, it's Parts are brought closer together, it hath a greater degree of Solidity and Firmness, when Froze again ; the *Texture* being much more close and compact, than that of the Snow.

But by some it is taught, that Induration depends on a certain inward Principle, or a Plastick Power, called by some a *Form* and by others a *Petrifying Spirit*, lodged in a Liquid *Vehicle*. And indeed, since I have observed, that some Stones dug out of the Earth are endued with such curious and exquisite Figures, as if they had been the product of Art ; I cannot but acknowledge a Plastick Power, which the wise Creator of Things hath implanted in certain Particles of Matter, which produce both the determinate Figure as well as consistence of those

A Plastick power inherent in Bodies.

Plastick
Power
what?

Bodies: But we disagree with the generality of those *Philosophers*, as to the Manner in which this internal Principle produces its Effects; and since the Manner of it, by them, is not intelligibly explained, it will be necessary to Consider, how many ways Nature takes to render Bodies Solid, by which we shall be better Qualify'd to Judge of the Manner which those Particles operate by, in which the Plastick Power is said to lodge.

But to proceed; For as much as Hardness is the highest degree of Firmness, we shall endeavour to make it appear, that an Alteration of *Texture*, concurring with other dispositions of the component Parts of a Body, is enough to render it hard without the Addition of an adventitious *Salt*.

The Tradition is common amongst those, that search into the Secrets of Nature, that *Coral*, tho' a hard Substance with us, is a soft Body whilst remaining under Water, according to that of *Ovid*,

*Sic & Corallum quo primum contigit Auras
Tempore durescit, mollis fuit herba sub Undis.*

Ovid. Metamorph. Lib. 15.

And tho' *Beguinus Tyrdecyn. Chym. lib. 2 Cap. 10.* hath urged very strong Arguments against this Tradition; yet, that it hath sometimes been found true, appears from what *Gassendus lib. 4 An. Dom. 1624.* relates of an Ingenious Gentleman, who Fished for *Coral* near *Toulon*, viz. The Plants, which were pluck'd up, and drawn out, were neither red nor handsome, till their Bark

Bark was pulled off; in some Parts they were soft, and would give way to the Hand, as towards the Tops, which being broken and squeezed, they sent forth Milk like that of Figs. To which may be added the Testimony of the Jesuit *Fournier*, *Hydrograph. lib. 4. Cap. 27.* And I am informed by one that Practises Physick in the *East-Indies*, that he gather'd white Coral divers times on the Sands of the Island *Mehila* (not far from that of *Madagascar*) which is usually as soft as an Onion; and is observed to decay, if it is not gathered at a certain Season of the Year, Agreeable to which *Piso lib. 4. Cap. 68.* making mention of several stony Trees on the *Brasilian Coast*; says, *E fundo eruta mox durissima; si insolentur in Litore, sicca niveique coloris fiunt*, which may be favoured by the following Relation of *Scaliger's*. *Ex bovillis Oppidanus adjutus Medicamenti eminxit vitrum sane ex illa Nobili Paxagora pumita dum mingeretur, albuminis Mollitie, emission vitri duritie ac splendore, Senatoris filius eiecit, putris modo multis, & maximos: Qui aeris Contactu, postea in Gypseam tum speciem tum firmitatem concrevere; hic quoque nunc recte valet.* And I have been informed by a Merchant, and likewise a Chymist of *Dantzick*, that several Lumps of Amber have been taken up soft upon their Coast which presently grew hard in the Air; which I the rather believ'd, because I have several times observed, both Spiders, Flies and Straws enclosed in Amber.

And here we may take Notice, that tho' it from hence appears, that some Bodies which are soft under Water, become hard when exposed to the Air; yet it is a Matter of difficul-

Observations of Indurated Bodies.

ty to determine, how much, the Influence of the Air contributes to the hardning of them : For *Gassendus in Vita Piereskii*. lib. 1. Says, he hath observed in the lesser Streams of the River *Rhofsne*, where he usually washed himself, several Lumps of hard Substances, upon the same Place, where he was wont to find the ground smooth and soft ; and that some time after, the same hard Substances remaining in the Water, as well as some which he carried home with him, were turned into perfect Pebbles; from which relations, and also what we have before observed concerning the Powder of Alabaster, it appears, how much the Mechanical Textures of Bodies, together with other Mechanical Qualities contribute to their various Forms; for besides the aforementioned Instances I have observed, that that bony Substance, so much esteemed by *Physicians*, which is usually taken out of the Deer's Heart, and is of a hard Consistence, hath appear'd, in one of those Creatures which I purposely look'd into, to be soft and flexible like *Cartilages*.

And indeed Solidity seems so much to depend upon Texture, that it may justly be doubted, whether the most solid Bodies have not before their Concretion been in Fluid Forms; since amongst other Rarities I have seen, in the midst of Stones, the exact Figures of Fishes with their Scales and Finns, &c. And I have known, not only Wood, but several other Substances as *Lead-ore*, *Minera Antimonii*, *Marchasites*, &c. found in the midst of stony Concretions; which are strong Arguments that those Stones have been before their Indurations in the Forms of

Fluids

Fluids; and from hence we may have ground to Question the Opinions of some, who think, that Stones and such like, or more solid Concretions, have been existent in the same Forms since the Creation; since we may with probability enough presume, that these Concretes are the Results of Matter, newly modified; and united after a different Manner from what they were before; otherwise it would be impossible, that such things should be lodged in such hard Concretes; And these Considerations and Observations may farther confirm, what we have elsewhere noted concerning the growth and increase of *Minerals*.

But the most eminent Instances, to shew, how much the *Fluidity* and *Firmness* of Bodies, is owing to the Texture and various Coalitions of their Parts, are in those Waters, which when permitted to rest, instead of *Fluidity* acquire a stony hardness. And it hath been observed in some hollow Caves, that by the Coagulation of a certain Humor, which issued out of the top of it, several Concretes have been formed like Icicles; of which I have some by me now, gathered by a very ingenious Person, which are of a perfect stony hardness, being 8 or 10 Inches in Length, and of a proportionable Thickness; and I have also now by me, certain stony Concretes sent me from a famous petrifying Cave in *France*.

And if we will give Credit to *Aventinus* as well as some other Authors, he hath recorded, in his History, that several Men and Women were at once Petrify'd by a *Terrene Spirit*, and changed into Statues; that Petrifying exhalati-

A very remarkable Instance to shew how much Fluidity, &c. depends on Texture.

Mixture
sufficient to
produce Pe-
trification.

on operating much after the same Manner, and altering the *Texture* of their Bodies, as when by Incubation and the subtile Insinuations of calorifick *Atoms*, the Parts of an Egg are so newly modified and disposed, as to put on the Form of a Chick. And it is Testified by *Pamphilio Pixcentino*, of a Woman in *Venice*, who upon eating of an *Apple*, was turned into a very hard Stone, after she had been hideously tortured for about 24 hours; which History together with Observations of my own, which I shall add, will be a good Argument to prove, that even Mixture is sufficient to petrify some Bodies; the Observation is in the following *Experiment*, viz. If two Ounces of *Quick-silver* be mixed with two Ounces and a half of *Verdigrise*, together with about an Ounce of common Salt, and put into a Frying Pan; when that Mixture hath been Boiled for a considerable time, with an equal Quantity of Vinegar and Water, gradually infus'd, as it wafts by Effluvi-ums, the Mixture, washed and cleansed from its Salts, will afford an Amalgama not unlike *Quick-silver*; which, if Dexterously prepared, may be cast into Moulds and formed into imbest Images; and it is in this Amalgama very remarkable, that tho' at the first it is so soft, as in a great Measure to emulate a *Fluid* Body; yet when for some hours exposed to the Air, it becomes hard and as Brittle as Steel; where the Induration seems to result from the Coalitions of the mixed Ingredients, and their new Texture, rather than from any innate Principle; The Particles of the Fluid Mercury being so intangled and interwoven one with another, as to lose their former Fluidity,

and

and to convene so closely as to unite into a Solid Body. And that the Induration depends on a Mutual Combination of the Saline Ingredients with the Mercury, is beyond doubt; since not only a true and perfect Copper may be obtained from the Amalgama; but when it hath been for some time exposed to the Air, the Surface will be covered over with the Saline Parts of the Verdigreese, which have freed themselves from their more intimate commixture with the metalline Particles of the condensed Quick-Silver.

But lest it should be Questioned, whether the Particles of Salt can have any sensible Operation, when mixed with a Body so firm as condens'd Quick-Silver, I shall add, that in Bodies much more firm, it hath been observ'd, *viz.* in those Stones from which Vitriol is got; for it is remarkable in them, that when they have been for some time exposed to the open Air, the internal Agitation of the Saline Parts, is so violent, that several of them will not only swell, but even burst asunder. And I remember that having preserv'd a Mineral, much of the same Nature with these Stones, in my Chamber, the Superficies was cover'd with a Powder, both in Colour and Taste resembling Vitriol.

And that the Motion of the Parts of this Amalgama, whilst it was Fluid, which they might be put into, by the external force of the Fire, might contribute to their Concretion, we have sufficient Reasons to believe, from what is related and observ'd by experienc'd Masons, *viz.* That the best Morter will not acquire it's utmost compactness, under 25 or 30 Years, and that, after

a long time, it becomes so hard, as to be more unapt to break than the Stones or Cements.

But lastly, that the Condensation of the Parts of the *Quicksilver*, depends on the Mixture of the Ingredients, and the Texture thence resulting, is evident; since the Proportion of the Ingredients being vary'd, the Condensation of the *Mercury* was neither so speedy, nor so firm.

A Strange
Sort of
Earth.

And that it may appear, That *Nature* and *Art* sometimes take Measures not unlike, in the Hardning of Bodies, I shall add a Passage from a *Jesuit*, nam'd *Pierre Belleprat*, who relates it as an Observation in the *American* Continent, where he was sent to preach to the *Indians*: The Relation is, That near the Mouth of the River, there is to be found a Green sort of Clay, which being soft, and capable of being put into any Form, whilst under Water, grows so hard when expos'd to the Air, as not to be much softer than Diamonds; and this, he says, the Natives usually make Hatchets of, which they cut their Wood in pieces with. But,

A Concrete
resulting
from a Mix-
ture of Spi-
rit of Wine,
and a So-
lution of
Coral.

To conclude this *Discourse*, I shall add an Experiment, which will be a farther Confirmation, That *Fluidity* and *Firmness*, depend on Texture, and the Motion or Rest of the Insensible Parts of Matter. The Experiment is, That having made a Solution of *Coral* in *Vinegar*, so strong, that part of it fell to the Bottom; I pour'd *Dephlegm'd Spirit of Wine*, upon the Clear Decantated Liquor, so gently, that it might swim upon it for some time; where it was surprizing, that upon a violent Agitation, the two Liquors being mix'd together, united into a *Concrete* so firm, as not to afford the least Drop

Drop of a Fluid Liquor; yet by adding an equal quantity or thereabouts of Spirit of *Nitre*, it would again lay down that *Viscidit*y, and become a Transparent Liquor.

And here it will not be amiss to specify, That this *Experiment* is so difficult, that it scarce succeeds, without a great deal of Caution; for, First, If the *Tincture* be not strong enough, or the Spirit of *Wine* not rectify'd, the *Coagulation* will be but partial, and not so quick: Secondly, The *Experiment* hath succeeded in a Wide-mouth'd Glass, where it had a free access of *Air*, tho' it would not in one which was closer: Thirdly, Upon an Infusion of Spirit of *Nitre*, the Mixture must be stirr'd with an Instrument, made of *Gold*, *Wood*, or *Glass*, lest the *Menstruum* corroding it, should render the *Experiment* unsuccessful: And Fourthly, The quantity of each of these Ingredients is hard to be defin'd, by Reason of the Difference in respect of the Strength of the *Tincture*, and the Spirituousness of the *Spirit*; but it is rather to be learnt, by Varying the Proportions, if the first Tryal does not succeed.

Having made this Progress in the *History* of *Fluidity*, and *Firmness*; It might be seasonable to pass on, and consider those other Qualities relating to it; as *Hardness*, *Brittleness*, *Softness*, &c. but remembring the Advice given by some of the Ancients, *Noscenda est Mensura sui*; I shall leave them for others, who are better able and more at leisure; being content, that I have explain'd the two former Qualities more Intelligibly, than some of the *Peripateticks*, or *Chymists*; having lay'd open a Way to accommodate *Chymical Experiments*

periments, to the Explanation of *Fluidity* and *Firmness*, so as to deduce those Qualities, from more Intelligible Principles, viz. *Size*, *Shape*, and *Motion*.

CH A P. XIV.

An Essay of the Intestine Motions of the Particles of Quiescent Solids.

The Signification of the Word Rest limited.

THE Word *REST*, is of so Ambiguous a Signification, that before the Question, *Whether there be in Bodies any Absolute Rest?* can be answer'd, it is requisite to consider, That in the Common Acceptation, it is us'd to denote, such a *Rest* as is not perceivable to Sense; but when taken in a more Strict and *Philosophical Sense*, it usually signifies such an Absolute Rest, as to intimate a total Negation of *Motion*. In which latter Sense, if it be taken, I will not affirm, That there is such a *Rest*, even in the Parts of *Solids*; since it is not improbable, but that there is *Motion*, tho' imperceivable by Sense, even in the most Solid Bodies. In favour of which Opinion, were it necessary, I should offer Arguments *à priori*, deduc'd from the Doctrine of the *Epicurean* and *Cartesian* Principles.

For should we allow the World to arise from a Casual Concourse of *Atoms*, and that there were actual Motion in all of them; it would not be absurd to think, That tho' in Forming *Concretes*, they are usually wound one within another, yet

yet there is a continual Endeavour to *Elasticity*, by which they continually strive to disentangle themselves, and to fly away, and consequently the Result of those Endeavours must be a *Motion* amongst those *Atoms*.

And on the other side, should we, with *Cartesius*, allow a Continual Circulation of a *Materia Subtilis* through the Pores of Bodies, we may imagine, That the Insensible *Atoms*, which constitute that Body, will be shak'd and disturb'd by it, tho' not so much as to be perceiv'd by Sense: So in the *Summer*, the Leaves are carry'd off the Trees with gentle Gales of Wind, which are not perceiv'd by those that stand some Distance off.

But not to enlarge upon this Point, it may appear, from several of the *Phænomena* mention'd above in the *History of Fluidity*, that the Particles of Bodies may be in Motion, tho' that Motion is not discern'd; and Particularly, that of *Water*; where tho' its Parts be in a very Various Motion, yet to Sense they seem to be as much at Rest, as those, which form the Glass, in which the Water is contain'd. And that there may be a like Motion, in the Substance of *Silver* or *Iron*, may be argu'd from what is evident to the Touch, or by throwing Water upon them when hot, it being peculiar Properties in them when hot, to burn the Fingers, and to set the Water a-boiling; and the like Qualities, tho' not so violent, may be rais'd without the help of Fire, by barely Hammering of *Iron*, or *Silver*; they not only, by that means, acquiring a Power to heat, but likewise to raise Water into Vapours.

But

Argument
to prove
Motion in
Solids.

But if to this it should be objected, That tho' the Motion be indiscernible; yet the Agent that gives it that Motion is not, since we can discern how those Qualities are added to it, and how the Alteration is wrought: I answer, That tho' a Vigorous *Loadstone*, appears to be drawn along it's Axis, and back again, the Alteration is not visible in the Body of the *Iron*; yet it certainly loses, after it hath acquir'd, those Noble Faculties, viz. it's Attracting and Directing Virtues properly belonging to *Magnetical Bodies*: But, that there may be in *Metals* a Motion, tho' not discernible, is further evident in a *Bell*; which a long time after it has been struck with the Clapper, continues to put the Air into an Undulating Motion; and thereby to cause very odd Sounds; which must be an Argument, that the Particles of that *Bell* are in a very nimble Agitation; otherwise they could not communicate Motion to the Circumambient Air; and thereby cause such a Noise in the Ear.

Objections
answer'd.

But I must confess there are two Difficulties, which occur to what I have been offering: As First, That it is hard to imagin, how the Internal Parts of such Solid Bodies should be work'd upon, by Agents so weak as the Air, and especially some parts of Matter more Minute, which are dispers'd through it: And Secondly, It may be question'd how any Parts of Matter can be mov'd so slow, if at all, as to be so long in moving from the Internal Parts of a Needle, to the Superficies, as our *Hyperbesis* requires: But,

To the First, I answer, That those External Parts are not the sole Causes of these Motions, but only assistant to the Principal; which is evident from
what

what hath lately been noted concerning the *Con-
nate* Dispositions to Motion, attributed to Mat-
ter, according to the *Epicurean* and *Cartesian Phi-
losophy*; and by the Effects of a *Loadstone* upon the
Needle, we may be taught to guess, what lasting
Changes may be produc'd, in the Textures of
Bodies, by the Influence of very Insensible Parts
of Matter. And as for the other Part of the
Objection, *viz.* The Slowness of Motion, which
Nature makes use of in some of her Works, are
altogether as inconceivable, as the Motion of a
Shadow upon a Dial, or of an Index upon a
Clock: And Nature may upon other Accounts,
and undoubtedly does, make use of Motion in a
degree yet more remiss. But not to insist upon the
Slowness of Motion, which Nature makes use of,
it may be otherwise offer'd against this Obje-
ction, that the Motion of the Insensible Cor-
puscles of a *Loadstone* cannot be suppos'd to be
in a Direct Line, since they must not only pass
through Pores very crooked and intricate, but
must also meet with several other Particles of
Matter, which will oppose them; and not only
drive them back, but also make their Passage still
more intricate and winding, by driving them
from one side to another, as well as several other
ways, by which their Motion may be retarded.
Besides it is but Reasonable to suppose, That it
is much more easy to keep a heavy Body in Mo-
tion in its own *Medium*, than to remove it from
that to another.

But to decline *Speculations*, I shall bring Instances Instances
alliedg'd. to confirm what I am about to prove, *viz.* That
the Corpuscles, which constitute Bodies, are in-
clinable to Motion, and that their Motion is
very

very slow: The first Instance I shall mention, is in a Spring made of *Steel*, which, tho' it be press'd and squeez'd together for some time, it will, upon a Cessation of that Pressure again, unbend it self, and recover its former Position; but if it be kept long in that compress'd Posture, it will by degrees lose that Power of Restitution, and continue in its crooked and unbended Figure: From whence we may learn, That tho' *Elastick* Parts may be endu'd with an Endeavour to expand themselves, yet they may be a long while in working their Effect; since we see, that *Steel* being put into a Springy Form, retains that Springiness for a long time.

*The Effects
of a Bar of
Iron held in
a Perpendi-
cular Po-
sture in a
Mariner's
Compass.*

But to confirm what I have been discoursing of, and to evince what considerable Changes the Air may Effect in the most Solid Bodies; I shall add this Observation, *viz.* That if one End of a Bar of *Iron*, held perpendicularly, be apply'd to the Point of a *Mariner's* Compass, it will force it away towards the *East* or *West*; but if the Position of that Bar be alter'd, it presently loses its Magnetical Qualities: Yet it is observ'd, That if this *Iron* Bar be kept long in a Window, it's Magnetick Qualities become much more durable and constant; from whence it appears, That the Air together with the Magnetical *Effluvia* of the Earth, may work changes very lasting upon the Particles of Solid Bodies, by insinuating themselves into their Pores; and that the Motion, which must needs be concern'd in altering their Texture, must likewise be very slow, since it cannot in a little time acquire such Magnetical Virtues.

But

But to proceed to a further Confirmation of what we have deliver'd, the first Observation I take Notice of is, that it is usually observ'd, That if *Lignum Vita*, which is one of the hardest Woods, be work'd before it be sufficiently season'd, it will be very fragile, and subject to break; so that curiously work't Vessels expos'd to the Sun, have broke in pieces: And it hath been observ'd likewise, That several Cavities have been found in the Substance of it, full of a certain Gum, which some People much esteem in *Venerical* Distempers; to which may be added, That in the Seasoning of this Wood, for some particular uses, it is requisite to keep it longer than others, so that less than twenty Years will not make it fit for some uses. From whence we may infer, That if this Wood requires so long time to acquire it's utmost Compactness, and to evaporate its Watery Parts, the Motion of those evaporated Particles, must not only be very lasting, and durable, but slow.

And if it be allow'd, that those Gummy Parts were collected in their Cells, after the Felling of the Tree, as it is highly probable; it will be further to our Advantage, because it shews how the Parts of a Gross Body do permeate the fine Pores of a very Solid and Inanimate Substance; where the Motion must need be very insensible and slow. But what is more strange, I am inform'd, that the Wood of which certain Musical Instruments are made, sometimes, tho' a much softer Wood than *Lignum Vita*, requires at least forty Years Seasoning, and does not acquire it's best Resonance under Fourscore.

N

But

Observations
made in
Quarries.

But further, That there is not only a Change of Texture in Solid Vegetable Substances, but even in *Stony Concretes*, appears from what is observ'd in Building; where some Walls acquire not their Utmost Solidity under forty Years. To which I shall add, what is further observ'd in some *Quarries* by *Masons*: And First, that there are *Marchasites* to be found, which being much more hard than Stones or Marble, and which consist as well of a Metalline, as a Stony Substance; yet have such a Degree of Motion in their Parts, as not only to burst, but, if long expos'd to the Air, to be cover'd over with *Viriolate Efflorescences*. To this I shall add, That an Ingenious Friend of mine had a *Turquoise*-Stone, in which there were certain Spots of different Colours from the Gem it self, which were observ'd to shift their places several times; which that there might be no doubt of, I employ'd one to take the Picture of it with those Spots in it, at several distant times, one after another, which Pictures, when compar'd, shew'd, that the Spots had shifted their Places; having pass'd up and down through the Substance of so solid a Gem, very slowly, in a Figure as irregular. And I am inform'd by a *Jeweller*, that he once had one of these Stones, which had a different Blue in two several Parts of the Stone; and that, in some time, the one overspread the whole, and mix'd with the other: And an Ingenious Friend of mine told me, That he had observ'd a certain Cloud in an *Agate*, to move several times from one place to another.

Motion in
the Parts of
Solids.

But there is not only an Intestin Motion of Parts in such Solid Substances as these, but in Bodies look'd

look'd upon to be of the Closest and most Compact Textures; for I have now a *Diamond* by me, which being rubb'd, will easily become *Electrical*, and shine in the Dark; which Qualities cannot be added to it, without a Change of Texture; and that in altering that Texture, there is an Internal Motion of Parts, will easily be evinc'd; because, otherwise the Texture could not be chang'd; and further, because a very gentle Agent is sufficient to put the Parts of a *Diamond* in Motion.

And to this Relation I shall add, That I have often observ'd, a Dulness and Clearness to succeed each other, in a *Diamond*, which I now have set in a Ring with the Former, which Changes could be attributed to no Manifest Cause: And I have observ'd no less surprizing a Change, in the several Degrees of *Electricity*, which could not be effected by any Cause that I could think of: And I have been inform'd, by one who had a certain *Hungarian Diamond*, that it would acquire a much greater Degree of Sprightness, by lying some time in Water: From all which it appears, That Considerable Changes may be effected in *Diamonds*, by Agents, which, to Sense, Operate very gently. And if *Diamonds* are generated in the Earth, as I have observ'd other Stones to be; it is reasonable to think, that the Hardness of their Substance, proceeds from the Closeness of their Parts, depending on the Internal Motion of their Insensible Corpuscles, by which they are brought to convene closer than ordinary: And this I am rather inclin'd to believe, because I have been told by an Eminent Jeweller, That the *Diamonds* of late Years, are
N 2 much

much more soft than those he formerly us'd to deal in: And the truth of this is further confirm'd, by what *Egrezes* a *Frenchman* writes of *Diamonds*, *P. M.* 17, 18. brought from the *Mine*, call'd *Gazerpoli*; the Sense of the Words is this: *They are very clear, and of a good Water, but they cannot be ground by Mutual Attrition, except with Stones of the same Mine: for if one should employ for that purpose, the Stones of another Mine, those of Gazerpoli would be broken in pieces: They do also easily break upon the Wheel, and those that are not vers'd in the Knowledge of Stones, may be easily deceiv'd in them.* And the same Author, speaking of another sort of *Diamonds*, says, That they sweat a sort of Unctuous Substance, which being wip'd off, as often renew it's Appearance. And to these I shall add an Account of a *Ruby*, which is one of the hardest *Diamonds*, one of which a Lady, nearly related to me, wore upon her Finger; which would often change it's Lustre, the Cause of which could not be assign'd; tho' these kind of *Phænomena* seem to be the Effects of some Internal Motion in their Parts, the Parts of *Diamonds* being capable of having their Parts put into Motion, without much difficulty.

But tho' it be hence Evident, That there is such an Intestin Motion of the Parts of *Diamonds*, yet it may be thought strange, to find the like in so firm and compact a Body as *Glass*. But that the Parts of *Glass* are not always at Rest, I am induc'd to believe, by the following Observations. First, That several Plates of *Venice-Glass*, have crack'd and broke in pieces, when no external Agent could have any Sensible Operation on them; which I conceive to proceed from

from a Redundancy of *Saline* Parts, which striving to fly away, break the Glass by their violent Motion; which Conjecture I am confirm'd in, since it is commonly observ'd, That there is a *Saline* Substance, adhering to the Surface of these Glasses in Cold Moist Weather. And I have observ'd in a Glass, into which too much Salt was put, to make it Diaphanous, several Cracks and Flaws, which it got in the Cold Weather: So that it rather appears to be a white, than a Glass-Cup at a Distance. And I, as well as those that deal much amongst Glasses, have observ'd, several to fly in pieces, when there was no outward Agent, to be the Cause of such an Effect; and I am inform'd by an Ingenious Man, who is Master of a Glass-House, That near a Third Part of a parcel of Glasses, flew in pieces of their own accord, after they had been kept for about five Years pack'd up. To which I might add several other Instances, to prove and illustrate the Doctrin above-deliver'd.

*The Parts
of Glass in
Motion.*

For these *Phænomena* may be, and are, very Naturally accounted for, by the Corpuscular *Philosophy*; for supposing, the Particles of Glass to be in a continual *Elastick* Endeavour to expand themselves, and fly away; and that several of those Particles are got together, it is no wonder that they break and dis-joint those Parts of the United Glass, which are least able to resist, and keep them from Expansion. And to Countenance this Explanation, I shall add, That several *Alkalizate*, or other small Parts of Matter, being inclos'd in the Body of a Glass, it is always apter to break, especially at that place, from

whence several Cracks spread themselves as from a Centre.

But whether the *Elasticity* of these Parts, be promoted by any Subtile Bodies, which penetrate the Glass, I shall not now stay to examine; but shall rather proceed to acquaint You, That in a considerable Space of Time, the Texture of Glass may be so alter'd, as to be more unapt to give a free Passage to *Aether* it self, or any other Subtile Body, which could penetrate it before; and consequently those Bodies Endeavouring to make their way, tho' oppos'd by it's Texture, cause a Proportionable Crack, or Dissolution of the Substance of the Glass.

Observations concerning the Intestine Motion of the Parts of Glass.

And to what we have deliver'd concerning *Glass*, these Observations are not altogether disagreeable; viz. First, That it is a Substance, which by being rubb'd easily, becomes *Electrical*; which is an Argument, that the Parts of it may without any great difficulty, be put into Motion. Secondly, The Parts of *Glass* may fly asunder, if the Neighbouring Parts be put into Motions disagreeable to each other; which is evident, if a hot Glass be immediately put into cold Water: for the Motion of it's Corpuscles, being externally checked, those which within remain in a violent Agitation, cause a sudden Disruption.

To which may be added, That tho' one would think the Particles of Glass were so fix'd, as to become unfit to alter their Figure and Shape; yet their Parts continuing in some Degree of Agitation, they may, by invisible and insensible Agents, be so work'd upon, as to be forc'd

forc'd to alter their Shape and Size: In confirmation of which, it may be observ'd, That White and pure Transparent Glafs, will in a little time, become very unfit to be put again into the Moulds they were first cast in.

But tho' I have mention'd both these Methods, by which the Cracking of Glasses, may be accounted for, to shew, that which soever of them we allow, they will be Proof of an Intestine Motion in the Parts of Glafs; yet I will neither examine or determine which of them is rather to be rely'd on; but shall only observe, That the Motion of their Parts must needs be very slow; since it is so long before it shews its Effects.

And now to conclude, tho' from what hath been deliver'd, it may be expected that I should draw Consequences, to determine whether there be absolute *Rest* in Bodies, or no, I shall omit that, and only intimate, That it is not absurd to doubt, nor improbable to think, that there is not; since it hath been discover'd in Bodies, which are usually esteem'd, most Quiescent.

CHAP. XV.

Of the great Effects of even Languid and unheeded Local Motion.

Several Phenomena arising from unheeded Causes, Comprized under the following Propositions.

TH O' several Mathematicians, as well as Philosophers, have exercis'd their Industry in limiting the Laws of Motion; yet since several Qualities usually esteem'd occult, may arise from a faint and unheeded Motion of the Parts of those Bodies, to which they are attributed, I shall consider the Extent of local Motion a little further: But before I proceed to consider the particular Effects of languid and unheeded Motion, I shall first premise, in general, what I have elsewhere upon another Occasion intimated, *viz.* That we are not to consider Bodies, barely as so many Portions of Matter endow'd with particular Powers; but as Bodies whose Particles are variously figur'd and modify'd after a peculiar Manner; so as to act or to be acted on by those Bodies which are about them; yet not wholly to derive their Effects to the Influence of external Agents, but in a great Measure from the mutual Action of one Part of Matter upon another.

But there are several other Circumstances of local Motion, besides what we have taken notice, which are not to be discern'd; and therefore I would not be thought wholly to attribute the *Phænomena* of a Body to Motion only but to

a Concurrence of several other Causes; but to avoid tedious Preambles, I shall take notice that the Reasons why some Men slight or overlook the strange Effects of languid Motion may be compriz'd under the following Heads.

I. Men are wont to overlook the great Efficacy Prop. I of Celerity, in Bodies which are very small: And especially, if the Space which they move through be but small.

What strange Effects may be deriv'd from rapid, tho' undiscerned Motion, we have a convincing Instance in Bullets, which by reason of their swift Motion, are able to effect more than those battering Engines of the Ancients, which were of a vaste Bulk in comparison of Bullets, which are shot out of the largest Canons: To this I might add several other Instances, but I shall rather proceed to alledge, in favour of the second Part of the Proposition, that I have often observ'd, That the Particles of Iron, which fly off Iron Rods, when they are turn'd, affected my Hand with a sensible Heat, if held at a small Distance; and it is likewise observ'd by those who work in Brass, That the Particles which fly off upon turning, affect their Eyes, as well as other Parts, with an offensive Heat; so that an experienc'd Workman shew'd me a Blister upon his Hand, which was rais'd by the intense Heat of Particles of Brass thrown off by a rough Tool. And I am further inform'd, That in turning of great Guns, the Parts which fly off are so hot as to burn the Fingers of those, who offer'd to take them up: Amongst which
Obser-

Observations it is to be noted, That Brass acquires a much greater Heat in turning than Iron.

And to these Observations I shall add, That not only the Parts of Metals, but Wood, will become in some Measure warm, by being put into a rapid Motion by the Force of the Turners Engines; from which Instances it appears how considerable are the Effects of a rapid, tho' a short Motion.

And we have Instances of this kind no less remarkable in Vegetables, where a good Cane by being struck with a Piece of Flint, emits Sparks not unlike Flint in a Moment of Time; and the like succeeds, if Loaf-sugar be dexterously scrap'd, so as to put its Parts into a brisk Agitation: But what is most worthy to be observ'd in Flint is, That it's Parts being put into a brisk Motion by another Piece of Flint, will not only assume the Form of Fire, but as the Ingenious Mr. *Hooke* hath observ'd, will be vitrify'd, tho' in Glass-houses both an intense Heat and an Addition of some *Borilla* are requisite to bring Sand or Flint to Fusion and to vitrify them: And that this Vitrification is made of the Portions of the Flint put into a brisk Motion, I am induc'd to believe, because one Piece of Flint will strike Fire upon another, without the Assistance of a Piece of Steel; and Fire may not only be struck out of Flint, but Bodies much harder, as Diamonds, which when grated on in a Mill have their Parts put into such a Motion, as to constitute Flame, though the most intense Degree of Heat will not dissolve them; and even the Parts of fluid Bo-

Bodies, if put into a brisk Motion, may have considerable Effects upon solid Bodies; for whether, the Beams of the Sun consist of Particles, which flow in direct Physical Lines from the Sun, or are only contiguous Matter, as the *Cartesians* think, put into a successive Motion, yet it is enough to countenance what is here deliver'd, that that Matter thrown into a *Focus* will melt Lead, Tin, or foliated Silver and Gold, and in a little time set green Wood on Fire. And how the small Parts of fluid Bodies will affect consistent and solid ones, will be further evident from Instances alledg'd under the fourth Head.

What I shall further offer here is the Strange The Effects of Lightning. Effects of Lightning, which, as several Histories, &c. testify, by the Motion and Minuteness of its Parts hath melted Metals in a Moment. Nor are the Effects of the Air in a Wind-gun upon a Bullet less to be admir'd; it's Parts upon the Account of their Springyness, being put into a violent Motion; for when the Air is permitted to expand, by affecting the Bullet no longer than whilst it passes through the Barrel of the Gun, the Bullet acquires such a Degree of Motion, as, upon it's being shot against a Plate of Metal, to be press'd into the Shape of an Hemisphere; and the Particles of the Bullet will be put into so considerable a Degree of Motion, by striking against the Plate, that I could scarce hold it betwixt my Fingers.

II. *We are inclin'd to think, That the insensible Motion of so soft Bodies as Fluids, can scarce*

scarce have any sensible Operation on solid Bodies.

By the Motion of fluid Bodies I would be understood to mean, not that which may be discover'd by the Eye or Touch, but the unperciev'd Motion of their insensible Parts; of the Effects of which, I might alledge several Instances from the Operations of Sounds upon solid Bodies; for upon the Discharge of great Guns, the Sound of their Explosion is not only heard a great way; but the expanding Gunpowder gives such a Motion to the Air, as to enable it to break Glass Windows at a considerable distance. And tho' to this it may be objected, That since the Cannon stands on the same Piece of Ground with the Houses whose Windows are so broke, the Effect may proceed from a tremulous Motion continu'd by the Soyl it stands on, yet the following Instance will make it appear, That the Parts of a Liquid being put into Motion may have such Effects; tho' it is not to be deny'd, but that a tremulous Motion may be given to the Earth, so violent as to be extended to a greater Distance; the Instance is, That the Water hath been put into so violent a Motion by an Engine contriv'd to sink Ships, that it shak'd several Ships which were at a considerable distance, so strongly, that those who were on the Decks could scarce stand.

And in the late great Sea-Fight between the *English* and the *Dutch*, tho' they engag'd at several Leagues Distance from the *Hague*; yet the *English* Embassador, who was then Resident there,

there assur'd me; that the Guns were not only heard thither, but that his Chamber Windows were considerably shaken. And some Bodies are so apt to receive Impressions from the undulating Motion of the Air, as to be sensibly, tho' not visibly affected; of which *Simon Pauli* in his ingenious Tract *De Febribus Malignis* p. 71. gives an Instance in these Words. *Atqui ager ille Gallus brachio truncatus, octiduum quidem superstit, sed horrendis totius corporis Convulsionibus correptus; qui quoque (ut & illa addam Observati- one dignissima,) dum in Domini sui adibus ad pla- team Kiodmoggerianum, Romanè, Laniorum appellares, decumberet, ac me ac aliis aliquandiu ad Lectum illius confidentibus quidem, sed nobis non attendentibus, explodentur tormenta bellica ex Re- gis ac Prætoris Navibus, sinistra truncum dextrâ brachii fovens ac complectens, toties quoties explode- rentur singula exclamabat ait, au, me miserum! Jesu, Maria, contundor penitus, adeo permolesta & intoler- abilis illi erat Tormentorum explosio, & quidem ex loco satis longinquo, terrâ non firma aut contiguâ, verum super salo aut mari Balshico, instituta: From whence it appears, that a Fluid Body may operate considerably upon a Solid, tho' the Mo- tion which causes such Effects be not perceiv'd: And of the Truth of the foregoing Relation, I am further assur'd, by the like Effects produc'd in the shatter'd Bones of wounded Men at Sea who have had sensible pain upon the Discharge of the Enemies Cannon.*

But lest in the aforementioned Instances it should be alledg'd, that these Sounds are rather propagated by the Earth, which the Bodies which receiv'd the first Impression leaned upon, than

than convey'd through the Air; I shall subjoin, that the Sound of Thunder is not liable to such Objections, since it can only be propagated through the Air; yet the Parts of the Air are in so Powerful an Agitation; that they have been observ'd to shake, not only Houses but several Ships at Sea.

But these Effects will not be thought strange, if we reflect on what hath been observ'd to be produc'd by the Celerity of the Motion of the minute Parts of a Body; especially if we likewise consider, that Sounds are propagated with greater Celerity than any thing we know besides, in our Sphere. For tho', as *Marsennus* takes Notice, a Bullet moves 240 Yards in the sixth Part of a Minute; yet I have observ'd Sounds to move 400 Yards in the same space of time. But tho' (it being granted that Sounds may be convey'd through the Air,) the Concussion of Houses or Ships at Sea might be suppos'd to arise from the Impetuous Motion of the Medium, violently shaken by an intense Agitation, where those Sounds were originally form'd; yet I conceive the Effects which those Sounds have on Bodies which are plac'd upon the Surface of this Globe, depend in some measure on the Dispositions of those Bodies to be work'd upon by such.

But to put an end to Instances alledg'd in Proof of this Proposition I shall add an Observation made by the Experienc'd *Platerus*, which shews, that a Solid Body may have such a Disposition as to be capable of receiving Impressions from the languid Motion of Air; for *lib. Observ. 1. p. 185.* He says, *Favina quodam in subitaneum incidit*

incidit morbum, viribus subito prostratis, se suffocari indefinenter clamitans, etsi nec Stertoris nec Tussis aliqua essent Indicia, maxime verò de aura quadam adveniente, si vel leviter aliquis adstantium se moveret, qua illam opprimeret, conquerebatur, seque suffocari, si quis propius accederet, clamitabat: Vix dum biduum in ea anxietate perseverans expiravit: To which he adds, Vidi & alios agros de simili aura, qua eos, si quis illis appropinquaret, in suffocationis periculum, induceret conquerebatur, quod semper pessimum est signum deprehendi.

III. Tho' the Number of Insensible Parts of Prop. III.

Matter put into Motion, enable them to perform several things, yet they are usually slighted because invisible.

The Effects of some subtle Parts of Matter are usually esteem'd very inconsiderable, by those who imagine, that these more subtle Effluvia of Bodies only Act upon the external Surfaces of others: But if we consider, that those Effluvia are not only very Numerous, but of convenient Figures and Sizes to penetrate into the inmost recesses of Bodies they work upon, we may attribute more powerful Effects to them than Men usually are wont to do; for as the Motion of the Effluvia are more or less strong, and numerous, they may either disjoyn or otherwise alter the Textures of those Bodies. As in an Ant-hill, whose Soyl is full of Eggs, by the Number and Motion of those little Insects; the Eggs which are up and down interspers'd betwixt the Parts of the Earth, will presently be separated and displac'd; or as the Leaves and Boughs

Boughs of a Tree are variously bent and broken off, by the force of the Invisible Parts of the Air which passes through it.

But to come to Instances which may more Illustrate what we are about; That the subtile Parts of Matter whose effects are less taken Notice of, are enabled, by their Size and Figure, to disjoyn the Parts of Bodies they work upon; we have an evident Instance in Sugar, and Amber thrown together into Water; for the Water presently divides the Parts of the Sugar, and totally dissolves them; whereas the Amber continues unaltred. To which Instance may be added one of no less Force, afforded by Chymistry; for if you pour limpid Water, upon that consistent Substance, which remains after an abstraction of five Parts of Oyl of Vitriol from one of Mercury, and shake the Mixture, the Calx will presently exchange it's White for a Limon-colour, the Texture of the whole Mass being presently alter'd,

And how powerful the minute Parts of some Bodies are, we may further observe in Spirit of Wine: For if a Piece of Metal be held in the Flame of it, these subtil Particles presently penetrate the Substance of that Solid Body; and so exagitate the Parts of it, as to put them into a Motion strong enough to Cause a sensible Heat. And we have not a less remarkable Instance of the Force of unheeded Agents in Animal Bodies and the Effects of those invisible Spirits which move through the Nerves, which by such weighty Masses of Matter, as the Bodies of some Animals, are violently mov'd up and down: To which may be added, that by the bare insinuation of Moisture into the Pores of a Rope, it
may

may be so contracted, as to raise above sixty pound weight, above the place those Weights were suspended at in dry Weather. And tho' Metals will endure the Heat of a Red-hot Crucible, yet may they easily be melted with the Flame of a Candle, if the Heat and Activity of it be promoted by a Blow-Pipe. And how much more able the Parts of an Agent, are to operate upon a Body, when they are intimately mix'd with that they are to work upon, than Superficially, appears from *Tartar*, which is much sooner calcin'd, if *Nitre* be so mix'd with it, that upon Deflagration, the Flame may be commix'd with all it's Parts, than if it only acts immediately on the Outside.

But to alledge Instances, which will be of more Force; tho' the *Effluvia* of a *Load-stone* be very minute, and the Body of *Iron* or *Steel* very solid; yet I have seen a *Magnet*, whose *Effluvia* were so powerful, as to attract and sustain fifty times the weight of the Stone it self. And to make it appear, how probably the *Effluvia* of a *Magnet* may change the Texture of solid *Steel*, and by that means endow it with those Qualities, which *Iron* usually derives from it; I plac'd Filings of *Steel* upon a piece of Paper, holding under it the Pole of a vigorous *Load-stone*, by the *Effluvia* of which, the Filings were presently so rang'd, as to represent several Needles, on Pikes, made up of Particles of *Iron*, sticking one upon another; and these might be mov'd up and down, by removing the *Load-stone*, from one place to another; but as soon as the *Load-stone* was remov'd from that place, to such a Distance, that it's Subtle Emanations had no longer any Influence upon the

*The Effects
of a Load-
stone upon
Filings of
Iron.*

Powder, the Parts of it presently lost that order, and fell into a confus'd Heap, as before that *Load-stone* was apply'd.

Again, tho' the Particles of Water be so small, as to be Invisible, and their Motion very weak; yet is it so powerful, that upon Freezing, the Expansion of the Frigorifick Parts are strong enough to break Bottles, not only of Glass, but Metal, and the Expansion oftentimes is so violent, as to exceed the Force of any other Body in expanding (except Gun-powder) that I know of.

CHAP. XVI.

Of the Propagable Nature of Motion.

Prop. VI.

IV. *It is usually not sufficiently taken Notice of, how Local Motion may be propagated through several Mediums, and even Solid Bodies.*

IT is usually thought, because some Bodies when they strike against Solid ones, commonly fly back, That the Impulse of that Body is not able to put the other into Motion; but that the Parts of a Solid may be put into Motion, and that that Motion may be propagated through such Consistent Substances, is evident, if we strike a piece of Timber slightly upon one End: For by that means, the Motion caus'd by that Impression, will be carry'd on to the other. And I have by Experience found, that having drawn the Point of a Pin upon the Brim of an Hemispherical Vessel, which

which was made of Bell-Metal, which is much harder than Steel, I found it, from a very slight Impression, to produce such a lasting Sound, as was an Argument, that the Parts of the Metal were not only put into such a Vibrating Motion, as to communicate it to the Air, but to continue it successively round the Brim of the Vessel, till the Sound ceas'd. And the like Propagation of Sounds I found to succeed, tho' the Point of a Pin were but struck upon that Vessel, which was seven Inches in Diameter. And indeed the Propagable Motion of Solids, when they are acted on by Fluids, is not less remarkable; since the Parts of a Bar of *Iron*, or *Glass*, may be put into such a Motion by Heat, as to have it continu'd to some Distance from the place where the Fire first work'd upon them, tho' it be capable of being propagated much further in the former of the two; which shews how much the Textures of Bodies dispose them to be differently work'd upon by the same Agent; and how much a Convenient Texture disposes them to be work'd upon at all.

And it may be further observ'd, That it is look'd upon as a Sign of the firm Connection of a House, that upon the Clapping of a Door, the whole shakes; and it is likewise an Argument of the Communicableness of Motion, whether it depends on the mutual Contact of the Door, and the Posts it shuts against, or upon the Impression made upon the included Air by the Door; for the former shews how a Solid may propagate Motion amongst Solids; and the Latter, how it may give Motion to a Fluid, and *Vice versa*.

But further, it is asserted by *Seneca*, that upon the Exploſion of thoſe Subterraneal Exhalations, which are the Cauſes of Earth-quakes, the Tremulous Motion of the Earth is continu'd above two hundred Miles: And *Joſephus Acoſta* witneſſeth, That it hath been continu'd for three hundred Leagues in the Kingdom of *Pernu*: And Learned Writers in the beginning of our Age (1601) witneſs, that the Motion of the Earth was ſo violent, as to ſhake moſt part of *Europe*, being propagated through moſt part of *Aſia*, *Hungary*, *Germany*, *Italy*, and *France*: And I have frequently obſerv'd, That the Houſe I have been in, hath ſenſibly ſhook, by the Tremulous Motion of the Earth it ſtood upon, propagated from ſome Coach or Cart, which mov'd at ſome diſtance upon the Ground; and ſome obſerving Scouts ſay, That, by the Motion of the Earth, they can diſcover the Approach of a Troop of Horſe at a good Diſtance.

And, to conclude this Member of our Diſcourſe, if ſuch Diſproportionate Cauſes, can produce ſuch Effects in Inorganical Bodies, well may they in thoſe that are Organical, where there is only wanting a ſmall Cauſe to call in the Aſſiſtance, and to determine the Cooperation of others; as the Tickling of a Feather in the Noſe, by Determining the Tendency of the Spirits, Cauſes Sneezing: And I remember, being once held with ſuch a Diſtemper, as depriv'd me of the uſe of my Hands; If, in the *Summer*, a Hair were but blown upon my Face, and continued there long, it would put me into Convulſions and cauſe me to faint.

But to determine another Member of this Proposition, viz. Whether Motion may be propagated, thro' several *Mediums*, or terminates at the utmost Limits of the *Medium* it was begun in, I shall offer the following *Experiment*; viz. I caus'd a Glass-Receiver to be blown with a Button, upon that part of the Internal Superficies which was uppermost; and suspending a Watch by a Chain, which was fix'd to a Soft Body, fasten'd upon the Button, I luted on a Receiver, to prevent a Communication betwixt the External and Internal Air; yet the Sound of the Watch might be perciv'd by holding One's Ears over that place, where the Watch was suspended. And I have often felt not only the striking of a Watch included in a double Case, when I have worn it in my Pocket, but even the gentler Motions of the Ballances.

To the Foregoing Instances, I shall add, That upon sudden Claps of Thunder, the very Beds have been perceiv'd to shake, by those that lay upon them: And *Agricola, de Nat. eorum qua fluunt è terra, Lib. 4. cap. 7.* says, *Si Animal dejicitur in Antrum, quod est in Carelia, Regione Scandiae, erumpit, ut perhibent, sonus intolerabilis magno cum flatu: Si leve pondus in Specum Dalmatiae, quamvis, inquit Plinius, tranquillo die, turbini similis emicat procella.*

But there are still some who are unwilling to believe, That Motion is propagable through Liquid Bodies; at least to any considerable Distance, because of the easy Cession of their Parts: But the contrary easily appears, if we allow of the Corpuscular Notion of Light; by Considering, not only how far the Rays of Light are

impell'd, and propagated from a small Light, but from the fix'd Stars, which are plac'd at so immense a Distance.

But to proceed to Instances, not so liable to Objections, that the Parts of Liquids, tho' in Motion, and Separate one from another, may communicate Motion, and propagate it a considerable way, is evident, by casting a Stone into the Water; which, by that Impulse, will successively propagate Motion in the Mass of Water; which appears by the Curling and Circular Streams which flow from it: And I am told by one who was us'd to Fish for *Whales*, near *Green-Land*, that sometimes, upon the Thawing of the Ice, it would give such Cracks, as to cause Sounds much lower than Claps of Thunder; and when huge pieces of Ice upon a Thaw, fell into the Sea, they caus'd such a Disturbance in it, as at two Leagues Distance to raise a considerable Storm.

And tho' some People are apt to think, That, the Air, being a Body much more Fluid than Water, Motion is less propagable in it; I shall intimate, that even in that *Medium*, a very small Sound is propagated, much further than we think of; for tho' we are not able to take Notice of it, beyond the Place where we stand, yet we may learn from *Ecchos*, that the Undulating Motion of the Air is continu'd a good way further; and it is not improbable, that it is continu'd further than the Place where the *Eccho* is made; since the Learned *Fromundus*, Professor of *Philosophy* at *Lovain*, in the Year 1627, says, That at the Siege of *Ostend*, the Noise of the Cannon was heard an hundred and twenty *English Miles*. To which
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may be added what *Verenius Geogr. Gen. Lib. 1. Cap. 19.* relates, as observ'd by *Trelchius*, at the Mountain *Carpathus* in Hungary: His Words are these, *Explosi in ea summitate Sclopetum, quod non majorem Sonitum, primò præ se tulit, quam si tegillum aut bacillum confregissem; post intervallum autem temporis murmur prolixum invaluit, inferioresque Montis partes, Convalles & Sylvas opplevit: Descendendo per Nives annosos intra Convalles, cum iterum Sclopetum exonerarem, major ac horribilior fragor, quam ex Tormento capacissimo inde exoriebatur; hinc verebar, ne totus Mons concussus, mecum corrueret; duravitque hic Sonus per semiquadrantem hora, usque dum abstrusissimas Cavernas penetrasset, ad quas Herundique multiplicatus resiliit, & talia quidem objecta concava in summitate. se non illico offerebant, idcirco fere insensibiliter primum Sonus repercutiebatur, donec descendendo Antris & Convallibus vicinior factus ad eas fortius impiegit.*

V. *The Effects of the Particular Modifications Prop. V. of the Invisible Motions of Fluids, on Animal Bodies dispos'd to be work'd upon by them, are not usually sufficiently noted.*

Tho' it may be thought strange, That the Impulse of so Slight and Languid Parts of Matter, as those of *Air*, should by their Motion, produce any Sensible Effects; yet, if we consider what a number of those Parts succeed each other, it is less to be admir'd, that the Effects of their Joynt-Action should be considerable, since we see, that a *Pendulum* of a Clock is continued in a swinging Motion, by a very Languid Force, and

the *Air* may be put into a Motion so powerful, either by the Vibration of the Strings, or the Mechanical Form of a *Musical Instrument*, or Scraping the Edge of a Knife upon Metal, as, to cause an Involuntary Excretion of Urine upon a Body rightly dispos'd, as it happened to a Knight of *Gascony*; or, to cause that Effect which is usually term'd, Setting the Teeth on Edge.

Besides which Instances, of the Effects of so Languid a Motion as that of the Air, I shall add, That I had a Servant, whose Gums would presently bleed upon tearing of Brown Paper: And Sir *Henry Blount*, as well as *Kircherus*, relates a Story of the like Nature; the former having observ'd in *Grand Cairo* in *Egypt*, a Nest of Serpents, which upon the Soud of a *Citron*, would presently crawl out of their Nests; and upon a Cessation of that Sound, run away again as fast: and the Latter tells us of a Fish about the *Streights*, which divide *Sicily* and *Italy*, which will be entric'd to follow the Ships which pass by that way, by the Sound of a *Musical Instrument*.

And that these Effects are produc'd by a sort of Disposition in those Bodies, to be work'd on by such Sounds may be confirm'd, by observing, That a Man is sooner affected and awak'd out of Sleep, by the Agreeable Sound of his own Name, than any other. And the Effects of a gentle, if a Surprizing Sound, are no less Remarkable, which will raise a Body from the Ground, which could not be so pois'd with some hundreds of Weights. But the most Eminent Instance is in Persons bit by a *Tarantula*, who, upon the Playing of a peculiar Tune, are compell'd to dance,

as long as it continues, tho' other Tunes have no such Effects on them; the Truth of which Relation is confirm'd both by *Epiphanius Ferdinandus*, and several Others: And I was acquainted with One, who told me, That a certain Lady could not forbear Weeping, when she heard a particular Tune play'd; and I have found several times a sort of Chilnefs upon my self, upon the Repetition of two Verses in *Lucan*, especially when I have been any thing Feverish.

To which Instances of the great Effects of *Languid Motions*, may be added, what is produc'd by the Subtile *Effluvia*, the Rays of Light causing those that come out of a dark Place presently to Sneeze: And Colours, which are but several Modifications of Light, have not less considerable Effects; which is evident from the Influence Red Cloth hath upon *Turkey-Cocks*: And the Learned *Valesius*, relates a Story of a Person, whose Eyes were much offended by Red Objects, which influenc'd him so much, as to cause an Effusion of Humours in the Adjacent Parts.

VI. *Men do not consider the Effects of Fluids Prop. VI. upon Inanimate Bodies, upon the Account of a Particular Texture and Modification of the Agent, and the Patient.*

That the Peculiar Modifications and Relations which Bodies have to each other, upon that Account, may contribute much to the Effects which the Languid Motions of the Air produce, and that upon that score, a weak Motion of it, may cause more considerable Effects, than Louder Sounds, not so aptly modify'd; I shall produce several
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Instances: For not to urge, That the String of an Instrument may be made to Vibrate it self, by the Motion it receives from the Instrument, and which that Instrument first receiv'd from another String, I shall rather offer the following Instance; viz. That a Strong Wire being made use of amongst other Strings on a *Musical Instrument*, it was observ'd, that the Wire would be made to tremble, by the Impulse of the Air, caus'd by a Sound which was made at a Distance, tho' the other Strings were not sensibly affected; but in this *Experiment* it is to be noted, That a peculiar degree of *Tension* is requisite, to afford the Foremention'd *Phanomenon*.

To this *Experiment* it may be added, That I have not only observ'd, that by making a Determinate Sound at some Distance from an *Hemispherical-Glass*, it would sensibly ring; but I have likewise taken Notice, That having screw'd several Strings of a *Musical Instrument* to a different Degree of *Tension*, and likewise plac'd several Glasses at some Distance, those Strings being put into a strong Degree of *Tension*, would cause one Glas to ring without affecting the other; and if the *Tension* of that String was alter'd, it would affect another Glas, but not the same: And what is more Remarkable, is, That tho' a String wound up to a Determinate Degree of *Tension*, would affect such a Glas; yet if the Foot of the same Glas were a little broke, it would not till it's *Tension* was alter'd.

And I have taken notice, That upon the Opening of some Stops in an Organ, the Sound hath been so considerable, as not only to cause the *Organist's Seat* to tremble, but a *Seat* in the Church, which

which was at a considerable Distance; and I could easily discern with my Fingers, that the Sound not only caus'd the Seat, but the Borders of my Hat to tremble: Which Instances shew, that the Effects of that Sound are not so much to be attributed to the Violence of it, as to the Dispositions in such Bodies to be acted on by it.

And to prove, That Languid Motion may have considerable Effects upon Bodies, both Solid and of considerable Bulk, I shall bring the following Instances: The First is, That an Ancient *Musician* affirm'd to me, that playing upon a Basse-Viol, he found, that when he struck a certain Note, it had always such an Effect upon a Casement, in the Room where he play'd to one of his Scholars, as to cause a Jarring Noise. A Second Instance is, That I observ'd in a certain Vault, that tho' a *Musician* vary'd his Notes on purpose, to make Tryal whether they would resound in the Arch, it would answer to but one Note; and I am told, that there is the like peculiarity in most Vaults.

VII. *Some Bodies are thought to have their Parts Prop. VII. in an Absolute Rest, when they are only in a state of Tension, or Compression.*

Tho' the External Superficies of a Body, seems to argue, That it's Parts are at Rest, since it retains it's Proper Figure and Dimensions; yet it is not improbable, but that those Corpuscles which compose it, are variously mov'd amongst themselves, or in a Tendency to Motion; An Instance of the First of which, we have in heated Iron, whether made hot by Actual Fire, or Hammering;

mering: For tho' the Eye can discern no Motion at all amongst it's Parts, yet the Touch perceives it manifestly hot: And tho' the Lath of a Cross-bow, or the String of a Bow, be look'd upon, when bent, as Bodies at Rest, yet the Springiness of the former, and violent Separation of the Ends of the Latter, when cut, manifestly demonstrates, that they were only in a state of *Tension*: To which might be added several Instances, taken as well from *Nature* as *Art*.

Of the Latter sort I have observ'd, That amongst Glasses, which to all appearance were well bak'd, several Months after they were made, some of them flew in pieces of their own accord; which they scarce ever fail to do, if they be taken from the Fire, and suffer'd to cool suddenly. The like to which I have observ'd, in a Metalline Glass of my own Preparation, which would shrink so much when remov'd from the Fire, as, if suddenly cool'd, to fly in pieces.

And if a piece of Copper heated to a Redness, or a Whiteness, be, upon Cooling, held over a piece of Paper, several Fleaks will presently fly off it; which seem to be Vitrify'd Metal, which, upon their shrinking, when expos'd to cool, fly asunder, like the Strings of a *Musical* Instrument in moist Weather.

And upon this Occasion, to shew how much Metals may shrink, I shall add, That I have found, that tho' a piece of *Iron*, when hot, would not go into a Cavity made in a Metalline Body for that purpose; yet when expos'd to the Air, and cool'd, it would shrink so much, as to be able to enter it: And to this, I shall add two Notable Observations; *viz.* First, That a certain *Artificer*, having cast

cast a number of Metalline Concaves, found, that tho' he took care to keep them from being expos'd to the Air, whilst cooling, and tho' they were of a considerable Thickness, and much harder than *Iron*; yet when they were leisurely cool'd to a certain degree, they would crack with a great Noise. The Second Observation is, That an Expert *Artist*, having cast a quantity of Bell-metal, and permitted it to cool about 12 Hours, upon the Area of an *Iron* Instrument, he found it considerably shrunk from the Instrument, and crack'd in several places: And the like Accident hath happen'd in *Brass*: for an *Artist* assur'd me, That having cast a Ring of *Brass*, about a Cylinder of *Iron*, upon cooling, it was so much shrunk, as to leave a Crack quite through on one Side.

From which *Experiments* it seems reasonable to infer, That a Body may be brought to a state of *Tension*, as well by being expanded by the External Force of the Fire, as any other external Agents; and also, That the Preter-natural states of Bodies, which they are brought into by some Agents, are to be look'd upon to depend on their Previous Dispositions, since tho' the Moisture of the Air will not cause a String of an Instrument to crack, which is moderately wound up, yet if it's *Tension* be much stronger, it presently flies in pieces: So likewise, if a Piece of Glass be hot in one Part, and cool in another, tho' cold Water dropp'd upon the hot Glass, will crack it, yet it will not have the same Effect on the Cool part of the Glass.

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From which and the rest of the *Experiments* contain'd in this Capter, it is apparent, that the Parts of Solids are not so much in a state of Rest, as of *Tension*, and *Compression*: To confirm which I shall add, That an *Experienc'd Artist* shew'd me a Lump of Matter, consisting of a great many *Agass* lodg'd in a Cement much harder than ordinary Stones; which *Agass*, he affirm'd would sometimes, when taken out of the Cement, endeavour to expand themselves so powerfully as to fly in pieces, in a little time after.

Prop. VIII.

VIII. *The Reasons why Languid Local Motion, and it's Effects, are so much overlook'd, is, because we are too apt to take notice only of the Visible Impressions of one Body against another without observing the Intestin Motions of Minute Parts.*

To prove this Proposition, I shall offer the following *Experiments*: And First, Having turn'd a Key in a *Brass* stop Cock, a considerable time, till the Metal, by frequent Attritions, became hot; I observ'd it at the last so to swell, as to stick fast like a Wedge, so that it could not be mov'd, till the Metal was again cool: And an *Experienc'd Workman* hath inform'd me, that in making such *Instruments*, before the Key could rightly be adapted to the Cavity it was to fit, he was forc'd to cool it several times in Water, to take down the Expansion effected by the Heat.

To this *Experiment*, it may be added, That the Parts of a Drinking-Glass, will be put into Motion,

tion, by drawing One's Finger round the Brim; and that so violent, as to toss several Drops of the Water contain'd in it, a considerable height into the Air; and a Drinking-Glass Artificially cut by a spiral Line, being dextrously inverted and shaken, will have its Parts so manifestly vibrated up and down, as to acquire a quarter of an Inch in Length, without any evident injury to the Glass. And it hath been observ'd, by one who made use of harden'd *Steel* Instruments to turn *Iron*, and shake off the Protuberances of that Metal; that in a little time it would acquire such a Heat and so lose it's Temper, as to look blue or yellowish, if it was not timely dipt in a convenient Liquor, to keep it cool. To this I shall add, That having two or three times bent a Bar of *Tin* in my Hands, backwards and forwards, I found, upon the Breaking of it, that the internal parts had acquir'd a considerable degree of Heat.

From which *Experiment* it appears, that Attrition of Parts, without a manifest Percussion, is able to cause a sensible Heat; and that not only hard, but soft Bodies, may do so too, I shall add the following *Experiments*, to evince, which is that an *Artist* having only rubb'd Optick-Glasses with *Putree*, upon a piece of Leather, to polish them, told me, that they acquir'd such a degree of Heat, as sometimes to crack; tho' I am not unapt to think, that such an Effect might as well be attributed to a peculiar Motion of the Parts of Glass, which were too violent; since from the aforementioned Vibration of the Parts of a Drinking-Glass, it appears, That they may be

be put into a considerable degree of Motion, without Heat: And that, by a very easy Friction, such Bodies may acquire a Tremulous Motion, appears from the following *Experiment*, viz. having suffer'd melted Brimstone to cool, in a Vessel whose Cavity was concave, I rubb'd the convex Superficies of the Brimstone, upon a Cushion for some time, and found, by applying my Ear to it, that the Parts of the Brimstone were put into such a Vibrating Motion, as to continue a crackling Noise for some time, after the Friction was discontinu'd. To which I shall add, That having rubb'd two Stones taken out of the Bladder together, I found them to yield a strong Urinous Smell: And not only Sulphur will emit Sulphureous Steams, by rubbing it upon Cloth, but *Diamonds* themselves will acquire a considerable degree of *Electricity*; and I have one by me, which, if rubb'd, will appear Luminous in the Dark.

And that it may further appear, that a peculiar Modification of Motion, may contribute to the various Effects produc'd by it, I shall observe, That those Stones which *Italian* Glass-men make use of, afford Sparks of Fire by Collision; but if moderately rubb'd together, they emit *fatid* Exhalations; from whence probably proceed those offensive Steams, emitted by Glass; and what is most remarkable, and to our purpose is, tho' Glass when Red-hot emits no such *Effluvia*; yet if two pieces be dexterously rubb'd together, they will send forth Steams copious enough and *fatid*.

And to shew how brisk the Motions of the Parts of inorganical Bodies are, and how soon they communicate Motion to one another, we need
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but consider, how the Tremulous Motion of a *Bell* is continu'd successively round it; and how, all that time, it communicates that Motion to the Air about it; for that the Parts of it are so successively kept in Motion, appears from that Trembling Motion, which may be perceiv'd by one's Finger: And it is further confirm'd, because a Solution of the Continuity much deadens, and causes the Sound to be much shorter: And that the Air receives its Undulating Motion from the Impress of the *Bell* all that time, appears, if One's Finger, or some other Body be apply'd to it, which stops that Tremulous Motion. And that the Motions in the Parts of the *Bell* are very brisk, is evinc'd from what is generally affirm'd, *viz.* That if a String be ty'd about a *Bell*, so as to check the Tremulous Motion upon the striking of the Clapper, it would break, some Parts being more agitated than others; so that the Disproportionate Motion compar'd with the Motion of the other Parts surmounting their Cohesion, they must consequently fly asunder: And,

As a further Argument, that the Parts of the *Bell* are so agitated, I put Filings of *Steel*, and Drops of Water into a *Hand-Bell*, and observed, That, upon the Impulse of a *Key*, the Water shiver'd, and the Filings had likewise such a Motion given to their Parts, as enabled them to dance up and down.

But to put an end to these Observations, I shall only intimate, That from what hath been said, it may appear, what considerable Effects may be caus'd by the Unheeded Motions of Invisible Parts of Matter, which are wont to be ascribed to other less Intelligible Causes.

CH A P. XVII.

A Supplement to the former Chapter of the Great Effects of Languid, and Unheeded Local Motion.

TO illustrate what hath been deliver'd in the former Chapter, I shall add the following Observations: And First, That the Motion of the Air may act on Bodies duly predispos'd, at a great Distance, appears from what the Learned *Borellus De vi Percussionis, Prop. CXI.* relates, viz. That being at *Tauromenium* in Sicily, about thirty Miles from Mount *Aetna*, when it first broke out, it was observable, that the Houses in that Town apparently shook, especially those which were most directly situated towards the Gap; which, as that Author observes, must needs proceed from the Impression of the Air upon the Houses: for had it been the Effect of a Tremulous Motion in the Ground, all the Houses would have shook alike, which was otherwise.

To prove that Motion may be propagated through different *Mediums*, besides what hath been before deliver'd, I shall add, That the Eloquent *Famianus Strada, De Bello Belg. Dec. 2. lib. 6. vel 7.* says, That a very Stupendious Work being rais'd by the Prince of Parma, to prevent the City of *Antwerp* from being reliev'd by the River *Scheld*, an Engineer contriv'd to blow it up, tho' with Success not a little Tragical, by a Boat fraught with Gun-powder, &c. for it rais'd such a Commotion, that the Earth shook to the Distance of 36 *English Miles*; and the deep Ri-
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ver was so agitated, as first to discover it's Bottom, and afterwards to overswell the Banks; the Castle, together with Men, Cannons, &c. being violently toss'd into the Air, together with a vast number of other Accidents horrid and dreadful.

And to illustrate further what hath been deliver'd in the foregoing Chapter, concerning the Effects of *Musick* on Bodies duly dispos'd to be work'd on by it; I shall add; that an Experienc'd Traveller told me, That in the *East Indies* he saw Tame *Serpents*, which would raise themselves erect in the Air, except 3 or 4 Inches of their Tails, which they rested upon: And he added, That upon the Playing of some Parts of the Tune, they would be put into very brisk and surprising Motions, whereas when another Part of it was a-playing, they seem'd to be half a sleep, and dissolv'd in Pleasure.

Another Instance, which shews how much the Peculiar Textures of Bodies contribute to their Effects, is publish'd by the Learned *Marhofius*, who relates, That *Nicolaus Petternus* had found out a Note, which, being loud and lasting, would, without visibly touching the Vessel, cause a Glass-Romer to tremble and burst; but if the Note were rais'd either too high, or depress'd too low, it would have no such Effect.

A further Instance of the Efficacy of *Languid Motion* is, That I once obtain'd several pieces of Glass, the Textures of which were so peculiar, that if the internal Superficies were gently scratch'd obliquely with a Pin, they would fly in pieces, tho' 6 or 7 times thicker than common Drinking-glasses.

To shew how much *Motion*, even in Solid Bodies, may be promoted by the Strokes of very weak Agents, I shall here relate, that several Urinals whose Parts were of a peculiar Texture, being rubb'd with Sand and Water, had their Parts put into such a Degree of Motion, as, in a little time after, to break without any Cause to be observ'd, except that precedent Attrition of Sand.

To make it evident, that the Parts of Solid Bodies, which seem to be at Rest, may have very powerful Effects, I shall add the following Observations.

First, That I have been inform'd, by a Famous Jeweller, That when he ground *Rubies* or *Sapphires*, or other Precious Stones upon a Mill, their Parts would acquire such a degree of Heat, as to afford Light like Fire; the Light flowing from each being of the same Colour with the Gem it came from: And I am likewise inform'd by another, that when they have acquir'd a certain degree of Heat, the Edges would gape; and if the Motion of the Mill was continu'd, the Gems would fly in pieces; but if it was stopp'd, the cold Gem would be whole and entire. To this *Observation* it will not be amiss to add, That, I once plac'd a Bottle, to which was adapted a Glass-stopple, in my Window, and about a twelve Month after, as I was sitting in the Room, the Top of the Stopple flew off, of its own accord, leaving the other Part fast in the Glass; but the Parts of Solid Glass will not only fly in pieces of their own accord, but I have been inform'd, that sometimes, in the *East-Indies*; *Diamonds* themselves, are observ'd to burst asunder, without the Impression of any Visible Agent.

THE

THE WORKS

Of the HONOURABLE
ROBERT BOYLE, Esq;
EPITOMIZED.

BOOK II.

CHAP. I.

*Of the Systematical, or Cosmical Qualities
of Things.*

CONSIDERING that the Particular Qualities of Bodies, depend on a certain Relation, which they have one towards another, by which they are adapted to Act or to be Acted on; I the rather chuse to call the Qualities consider'd in this Chapter, Systematical or Cosmical Qualities; they not being the Effects of those primary Affections of Bodies consider'd barely as such, viz.

*Qualities
proceeding
partly from
the Influence
of outward
Agents; as
well as the
Primary
Affections
of Matter*

P 3

Motion,

Motion, Size and Shape; but of Bodies so diversify'd by those primary Affections, Acting mutually on one another: As Quicksilver is endew'd with a Power to dissolve both Silver and Gold, and an Aptitude to be dissolv'd in *Aqua fortis*. So that I would not be understood to mean, by Cosmical Qualities, such as may be attributed to the mutual Actions and Passions of Bodies, plac'd in some imaginary Spaces beyond the World, but plac'd in the Universe, as now Constituted, with a vast Variety of Bodies about them.

This I have already hinted in the foregoing Chapters of Forms and Qualities; and therefore my design in this Chapter, is, to consider what Qualities a Body may Acquire, by the Impressions or Influence of Agents whose Effects are unknown, or not taken notice of.

And though all these *Phænomena*, which are usually attributed to the Laws of Nature, might properly be considered, in a Chapter that bears this Title; yet since those Agents most concerned in the Effecting of these *Phænomena* are either the Stars, the subterranean Parts, or the Æther and Atmosphere we live in; I shall wave those, and only here consider, what is requisite to prove, that there are such real Qualities, depending on unheeded Agents, and the Ordinary Course of Nature; but before I proceed, I shall briefly intimate, that our Notion of Cosmical Qualities is grounded upon these three Propositions.

Our Notion
of Cosmical
Qualities
grounded on
the three
following
Propositions:

1. That some Bodies are altogether inactive, till they are acted on; and that others, are put into Action, chiefly by the Influence of these Catholick and unheeded Agents.

2. That

2. That there are several Bodies, which when put into Action, are subtle enough to insinuate themselves into the Pores of other Bodies, which they are by the Established Laws of Nature forced to act on.

3. That an Alteration of the Mechanical Texture of the Body, is enough to dispose it, or render it unapt to be worked on, by those unheeded Agents. And these three Propositions I shall endeavour to make out by the following *Phænomena* and Experiments.

To begin then with the first Proposition, *viz.* *That some Bodies are altogether inactive, till they are acted on; and that others are put into Action, chiefly by the Influence of these Catholick and Unheeded Agents.* *Proposition the first.*

The first Part of this Proposition, I presume undeniable, if we consider, That till a Hammer, or some other Body be struck upon a Wedge, it wants the Power or Faculty of cleaving Wood, but when forced by the Impulse of that Body, which strikes upon it, the Wedge presently insinuates it self betwixt the Parts of that Solid, and divides them; As also, that a Knife is altogether unable to attract a Needle, till it hath received that Power from a Loadstone.

But to proceed to the second Part of the Proposition; I shall, to what I have elsewhere observed (*viz.* That the Property of a Burning-Glass, in respect of it's Effects, does not proceed from the Convex Figure, considered as such, but the Rays of the Sun cast into a Point) add the following

Motion, Size and Shape; but of Bodies so diversify'd by those primary Affections, Acting mutually on one another: As Quicksilver is endew'd with a Power to dissolve both Silver and Gold, and an Aptitude to be dissolv'd in *Aqua fortis*. So that I would not be understood to mean, by Cosmical Qualities, such as may be attributed to the mutual Actions and Passions of Bodies, plac'd in some imaginary Spaces beyond the World, but plac'd in the Universe, as now Constituted, with a vast Variety of Bodies about them.

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lowing Instances. The *first* is, That a Bar of Iron, by standing a considerable time in a Window, in a perpendicular Line, will acquire a considerable degree of Magnetism, by the Influence of Invisible Agents; and several Magnetical Qualities which it hadnot before. *Secondly*, That tho' a flat Piece of Marble, considered barely as such, hath not a Power to raise any Body by a bare Contact; yet if it be applyed to another, whose Superficies is adapted to it; by virtue of the Constitution and Fabrick of the World, and the concurrent Causes of Bodies about it, it may acquire such a Faculty, the lower Stone being boyed up by the Weight and Pressure of the ambient Air; yet, if these two Stones were contained in a *Vacuum*, they would not have such a Power to lift up one another. But to proceed to

The second Proposition.

The second Proposition; which is, *That there are several Bodies, which, when put into Action, are subtle enough, to insinuate themselves into the Pores of other Bodies, which they are, by the Established Laws of Nature, forced to Act on.* And here, though some of the Experiments to be related, might be also alledged in favour of that *Aether* or *Materia cælestis*, which some Philosophers have supposed to be dispersed throughout the World; yet the Invisible Agents, which are here to be mentioned, are only such as the Magnetical Effluvia of the Earth, and also the Air, in reference to it's Spring and Weight.

And first, Tho a Bar of Silver, and another of Steel, be exposed to cool, when red hot, with their ends directly North and South; yet the Textures of these two Metals being different one from

from another, the Pores of the Steel, being opened, and the Metal made plyable, it is by the Insinuation of Terrestrial Effluvia, endued with several Magnetical Qualities; and particularly, when poised, to point North and South; whereas Silver acquires no such Properties. And that it may be less strange, that the Earth should afford Magnetical Effluvia, which are imagined by some to be very spirituous Ones, I shall add, that having heated an Oblong Loadstone, and exposed it to the Air to cool, with it's Ends pointing North and South, and so deprived it of it's Magnetical Qualities; I could make either End to tend to the Southern or Northern Pole, as, upon Ignition, I suffered it to cool with one end directed either North or Southwards.

To this it may be added, That if the Air be exhausted in some measure out of a Vial with an oblong Neck, and, upon it's Immersion in Water, ones Finger, which prevented the retroadmission of the Air, be presently taken away; the Water will contrary to the Tendency of it's own Gravity, presently fly up in the Bottle, being squeezed in by the External Pressure of the Air, lying upon the Surface of the Water, the Spring of the Internal Air, being so weakned, as not to be able to oppose the force of it; whereas in a *Vacuo* the Water would not be so raised, having no external Agent to boye it up.

Again, being desirous to know the Causes of ^{The Expansive force of Beans soaked with Water.} Germination, and from what Causes, that powerful Intumescence of Seeds, when sown, proceeded, I filled several Vessels of Glass, as well as Earth, with common Beans, filling up the Intervals with Water, and tying the Corks fast with Strings;

Strings; which being done, when the Beans had imbibed Water enough, their Intumescence was so powerful, as not only to break several of the Vessels, but a great many of the Strings which hindred the raising of the Corks. But that I might be more exact in estimating the Power of that Expansive Force, I put a sufficient Quantity of Beans and Water into a Brass Cylinder, whose Diameter was two Inches, and it's Length six; which being done, and the Orifice of the Cylinder being likewise fitted exactly with a Plug, a Trencher was placed upon it, which was broad enough to bear a half hundred weight of Lead: In which Experiment it was to be observed, that in two or three days, the Expansive Force of the Beans had raised the Plug a considerable Height. And it may further be noted in such Tryals, that as the Diameter of the Cylinder is larger, so the Expansive Force of the Beans are able to raise a more considerable Weight.

How far these Experiments may confirm the Corpuscularian Philosophy, or whether that Force may be Mechanically explained by it, I shall leave the Reader to consider, and shall here only observe, That the Air, together with the *Aether*, may in a great Measure concur to the producing of some of the *Phænomena* of Nature, which we imagin it very little concerned in; for besides the Effects which may be ascribed to the Pressure of the Air, it contributes to the producing of some upon another Account; it being easy to be observed, that Flesh may be preserved longer from Putrefaction, by being secluded from the Contact and Influence of the Air; and also, that the Light which flows from rotten Woods,
and

and some putrefyed Fishes, will appear and disappear upon the Contact or Separation of ambient Air.

But for a further Proof, that the Air may effect several things, besides what it produces by virtue of it's weight by the Insensible Motions of it's Parts; I might add, that whereas a Piece of Paper being wet with Oyl, hath it's Pores so altered, as to be capable of transmitting more easily the Rays of Light; and the Air being impelled, by the Laws of Nature, presently acts upon it, and represents a great many Objects, by being reflected from those Bodies beyond it, which could not appear through it before.

Several Phenomena produc'd by the Virtue of Motion in the Parts of the Air.

And if a large Box be so contrived, as to have one end of it open, and a Hole in the other end, covered with a Lenticular Glass; if the open end be made up with a fine sheet of Paper, and a small Hole be likewise made upon the Top of the Box; by placing ones Eye to the Lenticular Glass, one may discern upon the Paper the Lively Representations of External Objects, and their various Motions as well as Shape and Colours; which *Phænomena* could by no means be exhibited, were not either some Insensible Corpuscles, transmitted in the Form of Effluvia from those Objects, or some other subtle Particles of Matter, directed by Local Motion from the Object to the Paper, and from thence to the Eyes.

From whence it appears, that the Established Laws of the Universe, in a great measure, contribute to the producing of several *Phænomena*, which arise from the Operations of insensible and unheeded Causes: For a further Confirmation of which I shall add, That if a Bar of Iron be held

The Establish'd Laws of the Universe contribute to the producing of several Phenomena.

*How a Bar
of Iron ac-
quires Mag-
netical Qua-
lities.*

in a perpendicular Line; so that the lower end of it touch the Northren Point of a Magnetical Needle, it will presently drive it away; whereas, if the Position of that Iron Bar be so altered, as to touch that Point with the other end, it will, by a contrary Faculty, attract it, except the Iron Bar hath stood a considerable time in a Perpendicular Posture, exposed to the Air and the Magnetical Effluvia of the Earth, or hath lain a considerable time, pointing North and South, and so hath acquired a more durable Verticity. And if it should be asked; why, by such Postures, the Magnetical Qualities of Iron should be so much increased? it might probably be answered, that it proceeded from hence, *viz.* Because the Pores of the Iron, by lying nearer the Magnetical Effluvia of the Earth, have their Pores rendred more apt to receive and transmit the Effluvia of the Needle; so that consequently, that Part of the Iron which is most affected by those Steams, must become the stronger, and consequently the North Point of the Needle; for which reason, it must drive away the North Point of the Needle, and attract the South. But if on the contrary, the other end of the Bar be applyed to the Needle, by a contrary reason, it being less Magnetical, it must attract it. But not to insist upon this Explanation of the Magnetical Qualities of a Bar of Iron, I shall only observe, that it is necessary in order to acquire a durable Magnetical Virtue, that the Iron should stand long in that Perpendicular Posture, which is sufficient to prove what I contend for, *viz.* That the established Laws of Nature are requisite for the Production of several *Phænomena*, which would not be effected, were not those Laws observ'd.

But

But to proceed to the third and last Proposition, *viz. That an Alteration of the Mechanical Texture of a Body is enough to dispose it or render it unapt to be work'd on by those unheeded Agents.* *The Third Proposition.*
This is evident from what is practis'd at Sea, it being the usual Custom for the Sea-men, to throw Water upon their Sails to quicken the Motion of their Vessels, when pursu'd by Pirates; for the Threeds of the Sails being swelled with Water, and the Pores by that Means made less, the Wind, not finding so free a Passage through them, must consequently have the greater Force upon the Sail-Clothes, and so drive the Ship forwards more swiftly. Another Instance of considerable Effects succeeding a very slight Alteration in Texture may be observed, when, on a windy day, a Chamber-Window is left open; for the Wind, which before only shook the Glass, will presently blow the Curtains about and other things in the Chamber, which are in a Disposition to be easily moved, as Dust, Papers, &c.

But to proceed to Examples altogether not so gross, we may take notice, That though common Tartar will neither dissolve in the Air, nor easily in Water, yet when Part of it is driven away by Calcination, it readily dissolves and runs *per Deliquium* in a moist Air. To which may be added, that tho' a Loadstone by being heated in the Fire and cool'd again, underwent no visible Change as to Shape or Size, nor for as much as could be perceiv'd by the Eye, lost none of it's Parts; yet, by an invisible Change of Texture, effected by the Magnetical Effluvia of the Earth, it may alter its Verticity according to the

the different Postures it is permitted to cool in: And the like Change I have observed in Iron, whose Verticity was altered by a Change of Texture, wrought by so weak an Agent as the Earth.

To these we may add several Instances in liquid Bodies; and *first*, That, tho' Honey and Water mix'd together in an undue Proportion, reserve each their distinct Natures; yet if four or five Parts of Water be added to one Part of Honey, by some subtle Agents or other, they are presently fermented, and unite into one common Mass; and I am assur'd, by a Merchant who liv'd several Years in the *Canary* Islands, That if a Hogshead of Wine close stop'd be violently roll'd along; the Texture of the Liquor would be so chang'd, that, if it were but about a Month old, one of the Ends would be burst out, and the Liquor lost. Another Instance in which the Texture of the Body disposes it to be so powerfully work'd upon, we have in Glass, which upon a sudden Removal from the Fire into cold Water, is subject to fly in Pieces.

But an Instance which is more remarkable is, That a hot Plate of Copper being permitted to cool upon some which were more moderately hot in the Fire, and thence remov'd upon a Plate; several Pieces like Scales would fly off it, when expos'd to the *Atmosphere*; and

To conclude this Chapter, I shall add, That the *Bolanian* Stone acquires such an admirable Quality by Calcination, that, by being plac'd in the Sun-beams for some time, it gets such a Degree of Luminousness, as to retain it a

con-

considerable time, when remov'd into the dark.

CHAP. II.

Of Cosmical Suspitions.

THE World about us being stock'd with such a Variety of Objects, and other things, too small or subtle to be discern'd; it may not be unuseful, upon some Accounts, to propose Conjectures, where the Subject consider'd admits of no clearer Discoveries.

And *First*, it is not without Reason I suspect, ^{Suspicion} that, besides those uniform Parts of Matter, of ^{the First.} which the *Aether*, by some Philosophers, is thought to consist, there are also several other Parts of Matter, which are differently dispos'd to work upon Bodies, according to the various Textures of those Bodies they chance to work upon; or according to the different Agents they chance to work concurrently with: And this Suspicion is not improbable, since the inquisitive *Gilberts* hath not only discover'd the Magnetical Qualities of the Earth to be diffus'd on every side, but also it is commonly known that upon the Hunting of a Deer, several subtle Effluvia are left behind in the Air; which we should pass by unobserv'd, were there not such Creatures as Blood-hounds, endow'd with Organs fitted to receive those subtle Steams.

And it is, not a little strange, that several ^{A Second.} Persons should have such peculiar Temperaments,

as

as to be able to discover Pestilential Steams in the Air, for a considerable time before they are dispos'd to affect other Men; and that those Constitutions should be so dispos'd to be work'd upon by Effluvia, by others not in the least discern'd. And that there are such Bodies, as well as unheeded Effluvia, may be evinc'd by several Instances; as one which was remarkable in the Year 1665, in which, a certain Man, three Months before the beginning of the Plague, was taken with a Swelling in his Groin; which he had likewise as a Forerunner to several other Plagues. And *Fabritius Hildanus* relates a Story no less remarkable of himself; who, when, in his Youth, he had had the Plague, could never pass any House infected with it without a sensible Pain in that Part. To which may be added, a third Instance from that Curious Physician, who observ'd the various *Phænomena* of Distempers at the Siege of *Breda*, and says, *Annotandum hic meritò Natura Facultatem ad Pestis Præservationem Momenti esse maximi: Observavi in meipso contaminatos invisente statim inguina olere vel axillas; afficiebatur aliquando Caput, noctu inde Sudor, & secessus tres quatuorve; hoc & aliis accidit, qui fideliter mihi retulerunt.* And these Testimonies I am rather inclin'd to depend on, because deliver'd by Men of Judgment and Credit.

A Third.

Another Suspicion which I am about to relate, is, That the Laws of Nature, which contribute to the producing of several *Phænomena*, are not only of larger Extent than what we are us'd to imagin; but likewise concur to the Production of a greater Variety of Effects: For not

to spend much time in observing, That several Industrious Astrologers and Geographers, have, instead of Physical, given us Mathematical Hypotheses; having taken pains to describe the Situations and Motions of the fixed Stars and Planets; and likewise, that they have been industrious in discovering the four little Planets, which move about *Jupiter*; as also the little Moon, which runs about *Saturn*, as well as several *Phænomena* relating to Comets, without considering the Frame and Constitution of those Bodies, which compose our Globe; I conceive it not impossible to make it out, That there is a Commerce betwixt them and our Globe; as well as several Laws or Customs of Nature even in our own Globe not taken notice of by Scholastical and Mathematical Writers.

And I am, not without Reason, induc'd to *The Fourth* suspect, That this Globe of ours hath undergone several considerable Changes, not only in several Countries, but the internal Parts of it; That which is call'd the Mariners Compass, having been, in several Places, observ'd to vary considerably, in its Declension from the true North Pole; as for Instance, about *London* in the Year 1580 it declin'd eleven Degrees; in 1612 about six; and in the Year 1633 about four Degrees. And I have my self, at one time, observ'd little or no Declension, whereas at another I observ'd it to decline near half a Degree. And I am inform'd by one who often observ'd the Variation of the Compass at the *Cape of good Hope*, that, when he was a young Man, he observ'd it to decline two Degrees Westward; whereas of late, he found the Variation to be six Degrees

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and

and about forty eight Minutes; so that, by his Observation, it had vary'd little less than five Degrees, in the times he hath say'd past that Place. From whence we may have Reason to think, That there are certain Agents very powerful, tho' not to be taken notice of, which may work several, and very considerable Changes, even in the Terrestrial Globe it self; which whether regulated by any certain Laws of Nature, we know not.

And besides these, there are several other unheeded *Phænomena*, which we have troubled our selves very little to consider about; as the different Weight of our *Atmosphere*, and the Causes of that Difference; we having only noted that they proceed from some subterranean Effluviiums mix'd with the Air; but what other Effects those Effluviiums may have upon other Bodies hath been scarce discover'd.

Considerable Variations in the Temper of Climates.

And it is not a little strange, what Monsieur de Rochfort relates, concerning those Hurricanes observ'd in the *American* Islands; for, whereas, for a long time, they were observ'd to come but once in seven Years; yet in a short time they grew so frequent, as to return two or three times in the same Year. And I have been inform'd by an Ingenious Gentleman, that, having liv'd in *New England*, he observ'd a considerable Alteration in the Temper of that Climate; it being much less cold and more temperate than formerly. And Mr. *W. Wood*, in his Prospect of *New England*, takes notice of no inconsiderable Alteration; who says, That since the *English* Inhabitants settl'd there, the Showers

of Rain are much more moderate, though more frequent.

And the Learned *Magnenus* observes, in his *Tract de Manna*; That about three hundred Years ago there was no Manna to be found in *Cenotria*; and it is not above two Ages since Manna hath been found in *Calabria*, a Country so famous for it. And the Ingenious French Writer in his *History des Isles Antilles* Lib. 4. Cap. 6. says, That if the Juice of a Fruit call'd *Acajou*, falls upon a Cloth, it presently stains it red, which continues till the Tree bears Flowers again; which *Phænomenon* will be the more to our Purpose, if it may be doubted, whether it proceeded from the Temper of the Air or Length of Time.

But besides these *Phænomena*; when I observe the exact time, that the ebbing and flowing of the Sea keeps; and how exactly coincident with the New and Full Moon Spring-Tides happen; as also what vast Spring-Tides are constantly observ'd every Equinox; together with those various *Phænomena*, which may be observ'd in Sea-Water, which, in some Places and upon the blowing of some Winds, appears to be luminous, whereas other Parts are, at the same time, neither luminous, nor in the least affected, so as to become luminous by those Winds at any other time; I am very apt to believe, That these *Phænomena* proceeded from some Cosmical Law of Nature; or that the Planetary Vortex was not a little concern'd in producing these Effects.

Q. 2

And

Another
Suspicion.

And I am not unapt to believe, but that all those Distempers, which are either Endemic or Epidemic, proceed from a certain Influence, which those Globes which move about us, may have, together with some Terrestrial Effluvia, which are different in several Countries.

But not to engage in so fertile a Discourse as the *Phænomena*, which every particular Region affords; I shall only add two Suspensions more, which may be further Instances of the Established Laws and Customs of Nature.

A very con-
siderable
Phænomen-
on rela-
ting to the
Sun.

And first, it is a Question, whether those Planets, which move about our Globe, keep such constant Bounds in their Motion, and move in such Lines as Astrologers teach they do. And if we consider the vast variety of Bodies, contained in and about our Globe, it can scarce be imagined, that Nature should always keep to one constant and regular way of Acting, but that in several Particulars, she must deviate and operate variously; for not to mention, that Astronomers have observed, even Natural Days to vary in Length; and have disputed much concerning the *Anomalie* assigned to the Motion of the Sun's Apogæum; The Sun it self hath been sometimes observed, to be even obscured by opaque Matter, as in *Cæsar's* time, and at the beginning of *Augustus* his Government; when the Sun was for near a whole Year obscured. To which we may subjoyn the Number, Duration, and Vastness as well as Motion of some Comets.

And I am informed, that in the Northern Hemisphere, in that part of the *Galaxy*, which is not to be discerned by us, there are certain black,

black, and near the Northern Pole, white Clouds, which move along with the Galaxy in twenty four hours; and these may be discerned by those that sail 18 Degrees South Latitude; but I shall not insist upon these as Arguments, since I suspect those black Clouds to be nothing but the Azure Sky appearing through the Galaxy, and those white ones, to be only Constellations, like those of the Galaxy or the Belt of *Orion*.

But having hinted, that Nature may not always be exactly regular in the Motion of Planets, Nature may not always be exact in her Laws. &c. I shall here intimate, that sometimes we may think, those Motions which are Periodical and return at set times, irregular; because we live not long enough to observe the frequent Returns of such Changes, as we usually esteem Prodigies in Nature; for it would as much be thought strange, to see Trees blossom, and Fruit in the Summer, to a Man that lived but one Year, as several other *Phænomena* are strange to us, who have not lived long enough to have observed such *Phænomena* in their Periodical Turns before: So before the different Appearances of *Saturn* had often been observed, they were thought Prodigies.

But it is most remarkable, that several Stars have Periodically appeared and disappeared several times in the same Place, as hath been observed in the Girdle of *Andromeda*, and about the *Swan's Breast*, and another amongst the fixed Stars in the *Whale's Neck*. These I say are most remarkable, because they not only confirm what I have been saying of the Periodical Appearances of some *Phænomena*; but invalidate the Philosophical Systems of some, who allow of no

Vortices beyond the Concave Surfaces of the Firmament.

Vortices beyond the concave Surfaces of the Firmament: But if rather than to allow of *Vortices* beyond the Surface of the Firmament, we would imagin the Stars, which appear and disappear, to have dark and light Hemispheres, which Periodically turn towards our Globe; it will still be an Argument to question the Uniformity of the Motions of some of the Globes of the Universe; since at so vast a Distance, such considerable Alterations are observable.

But to conclude this Chapter; It may be a question, whether such prodigious Changes as are sometimes observed, may not by being frequently repeated, become a Custom, and have a Right to be reckoned amongst the Laws of Nature.

CHAP. III.

Of the Temperature of Subterranean Regions as to Heat and Cold.

FOR some Reasons, having been unable to examine into the Temper of the Air in subterranean Regions my self, I shall rather give such an Account of it, as I have received from several Persons.

The Temper of the Air in Groves.

And first, I shall relate a Story of the Temper of the Air observed by a Chymist, who purposely travelled into *Hungary*, which was the following: That going down into a Grove, at the first Entrance of it, he perceived the Air sensibly warm; but presently after for a quarter of an hour

hour in his descent, he felt it considerably cold; which cold Region being passed, he began to perceive it sensibly warmer, and the lower he descended the hotter it grew; so that, in the lower Veins, it was hotter than the Air above ground is usually in Summer: And this Relation was confirmed by a like Observation made by a Physician, who told me, that in a Mine, whose descent did not much exceed an hundred Fathom, the cold Region was extended near to the bottom of it. And this Relation is agreeable with what *Morinus* affirms, viz. That the Cold Region, in an *Hungarian* Mine, which he visited, was extended 80 Fathom, after which the Heat sensibly increased, the lower he descended; and the same Author affirms, that besides the different Tempers of those Regions, there is likewise observed, a different Degree of Heat, in the hot Region, correspondent to the different Seasons of the Year, viz. Winter and Summer.

These things premised in General, I shall now proceed to consider the Particular Regions of the Earth in the four following Propositions.

The Temperature of Subterraneal Regions consider'd under certain Propositions.
Prop. I.

PROPOSITION I.

The Bounds as well as Temperature of the first Region are very different. The Reason of both Parts of which Proposition are plain; since the Sun Beams must not only penetrate deeper in the Summer than the Winter; but also, because the solidity or porousness of several Parts of the Earth may dispose the Soil to Heat or Coldness.

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But

But to proceed, it is remarkable, that the uppermost Region is much more temperate, because both the violent Impressions of Sun Beams, and rugged Winds, are kept off by the sides of those Subterranean Cavities. And that the Power of the Sun Beams is much weakned by those sides, is plain; since, by such like means, the Heat of the Sun may be so broken, as to preserve Ice from thawing all Summer; and not only so, but if those subterranean Cavities be sufficiently guarded with a Cover of Brick, well clayed over; and be, by that means, preserved from any Intercourse with the External Air, it may be preserved without digging deep into the Ground, as is observed in the South Part of *France*; so that, though the Coldness of Subterranean Cavities may conduce, yet it is not altogether requisite to preserve Ice from a Thaw.

But the subterranean Regions are not only preserved from excessive Heat, by preventing the Intercourse of the Internal and the External Air, but may be considerably lessned in such Cavities as are considerably exposed to the open Air: as I myself have observed in an Iron Mine not above twelve foot deep.

And as it is to be observed, that this cold Region of the Air is not apt to be influenced by external Heat in the Summer, so neither is the hot Region subject to be altered much by the external Cold in Winter; which appears from the smoking of some Springs in Winter, which are supplied with Water, which had run a considerable depth in the ground, or passed through some Earth that was fitly disposed to warm it in its Passage.

But

But further, that Winters Cold is much more disposed to influence the superficial Region of the Earth than the hot one which lyes under it, appears from Reason it self, and may be further confirmed by observing, that even Water in freezing loses it's Fluidity, and puts on the Form of Ice, first in those Parts which are most contiguous to the Air, and subject to the Influence of External Cold: And it is observed, not only in *England*, but also in *Russia*, that if Wine or Beer be kept in a Cellar well roofed over, and about twelve foot deep, it may be preserved from freezing, notwithstanding the Violence of external Cold; where it is to be observed, that the Warmth of those Vaults, does not only depend on the Exclusion of External Air, but also on the Steams of those fermenting Liquors, together with some subterranean Steams, which are gathered there, and hindered from flying away.

PROPOSITION II.

Prop. II.

But to proceed to the Second Proposition, which may be comprized in the two following Members; As first, *That the Temper of the Second Member the Region of the Earth seems to be colder than that a- first.* This is both confirmed by Observations already cited, and also by Reason; by the latter, because the Earth, being a Body compounded of Parts less agitated than those about our Sensory, they must consequently cause a sensation of Cold; and why that Region should have it's Parts less agitated, than those about it is plain, because it lyes remoter both from the Influence

Why the Middle Region is colder.

fluence of External, as well as Subterraneal Heat.

But here it is to be noted, That though I say, the middle Region is coldest, yet I would only be understood to mean a comparative Coldness; for I by no means think that Region to be possessed with the most intense Degrees of Coldness, since neither Ice or Snow have been ever observed to be found in it: And though it be comparatively colder than those Regions about it; yet, that it is not the coldest may be hence argued, because it is observed in the Summer, that the Exhalations which steam from the middle Region are sensibly warm at the Orifice of the Grove; which they could not be, were the middle Region through which they passed extremely cold.

The second Member of the second Proposition.

But to pass to the second Member of this second Proposition; It is observed, *That in several Places, which may be referred to this middle Region, the Temperature of the Air is different at the same Seasons of the Year.* Which is evident both from Reason and Experience.

And first, from Experience it hath been learnt, by those who have often been in those *Hungarian Mines*, as well as some here in *England*. And indeed if we consider the different Heat in different Climates; but more peculiarly the Difference in Soils, it will not be less consonant to Reason; for the Soil may be more or less porous and compact; and may have different Substances mixed with it, or run through it, which may alter the Temper of it; for there is not always that Regular Order in Nature, which is in our Thoughts of her; since Salts, Marchasites and Minerals are dispersed

The different Temperatures of Subterraneal Regions may be varied by the Soil.

dispersed through the middle as well as the lower Regions of the Earth ; and may, by impregnating those Fluids which run through the Earth, cause different Refrigerating Effluvia to affect various Parts of the same Region ; as if, in one Place, it be impregnated with Nitre, and in another with Marchasitical Earth ; the Coldness of the former must render that Part of the Region the colder of the two. Besides, the Temper of them may differ upon the account of the Soil it self, which varies according to the several Degrees of it's Maturity ; so that for these Reasons, the Temper of Effluvia may be different in the same Place at one time from what they are at another in the same Place ; not to mention those Differences which it may undergo by several other Accidents, and the Subterranean Effluvia, which ascend more or less from the lower Regions.

And before I leave this Proposition, it may be necessary to advertise, That the different Degrees of Heat or Cold, in the several Regions of the Earth, are not easily discover'd by those *Thermoscopes*, which are usually made use of, to distinguish such Differences ; because the Pillar of Air, which presses upon the Liquor may differ in it's Pressure, according to the Length of it ; it being longer, and consequently heavier, the lower it descends.

But to pass to the Third Region compriz'd in Prop. III. the following Proposition, *viz. That the Temper of the Third Region is warm, which Warmth varies in several places.* That it is Warm, and that that Heat varies in several places, I think is sufficiently attested, by the several Persons that have gone down into those Mines ; but as for the Causes

Causes of it, those are not so easily discover'd: for I am not a little inclin'd to suspect, That considering the Closeness of those Cavities in which they work, the *Effluvia* of their own Bodies, and of the Metal they work in, may in some measure contribute to it.

The Effects
of Subter-
ranean Fires.

But to pass by this Suspicion, I shall rather briefly intimate, That I conceive the Earth to be stocked with store of Subterranean Fires; and that several Calorifick Qualities, being carry'd up through Clefts and Veins in the Earth, cause a Sensible Heat to be diffus'd through the whole. And that there are such Steams, appears manifestly from those Damps, which are often observ'd in Groves; not only in *England*, but *Germany*, *Bohemia*, *Hungary*, &c. which are sometimes so Bituminous and Sulphureous in Smell, as to be apt to take actual Fire.

But one thing I must intimate here, which is, That tho' I am inclin'd to believe, for some Reasons, this Argument valid; yet, I am not without a Suspicion, that notwithstanding the Aptness which these Exhalations have to take Flame; yet, even several cold Steams may rise from the lower Parts of the Earth, which may acquire Heat in the Upper Regions; for we see, that several Substances, which are apt enough to take Flame, have not the least sensible Heat in their Parts before; nay, are so far from that, that *Salt-Petre*, which is so apt to flame, will, by being dissolv'd in Water, add a considerable Degree of Coldness to it: And the like may be observ'd in Spirit of Wine, whose Spirit, tho' easily inflammable, affects not the Touch with the least Heat, if rais'd in the Form of a Vapor.

But.

But that which inclines me to be of the Opinion just now mention'd, is, That not only *Morinus*, but several others have observ'd, the Exhalations of Mines considerably hot in *Summer* time. And the Experienc'd *Agricola* hath observ'd, That the Mineral Steams which pervade the Earth, are so powerful, as not to permit a Hore-frost to lie upon the Ground which they lie under; and the like hath been observ'd upon Coal-Mines: And I remember, that an Acquaintance of mine shew'd me a piece of Land, which was so powerfully penetrated with warm *Effluvia*, that Snow would not lie upon it above two Days, were the Weather never so cold, which hath been confirm'd by frequent Observations; except where Layers of Rock, or some other Stony *Concretes*, obstructed the Passage of those Mineral Steams. To which may be added, That the Steams near Gold-Mines are so copious in *Hungary*, as to give the Leavs of the Trees a Golden-Colour.

But notwithstanding these Instances, I am apt to doubt, that there are several Parts of the third Region, which by reason of their Remoteness from such Subterraneal Fires, have not that Heat. But since these things are but uncertainly guess'd at, none having so great Curiosity, as to be at the Charges to dig deep enough without prospect of Gain, I shall rather proceed to consider, That, besides the foremention'd Causes, there is in some Mines such a degree of Heat, as cannot be accounted for without another Cause; the Incallescence being so great, as not to be produc'd without the Concourse of some other Mineral Steams, or Water to work upon, and promote the mutual Actions and Operations of the Volatile

Whence the
Unusual
Heat in
some Mines
proceeds.

latile and Active Parts of those Mines. And that such Incalescences may be produc'd in the Bowels of the Earth, I have elsewhere observ'd: And further, That Immature Minerals, such as *Marchasites*, whose Parts are impregnated with *Vitriol* and *Sulphureous* Parts, may, by reason of their Aptness to be dissolv'd, be able to cause such Effects, we may be induc'd to believe, because *Vitriol* hath not only been found in several Mines in *Hungary*; but likewise such Strong and Corrosive *Effluvioms*, as were very offensive to Respiration, and in a little time fatal to those that ventur'd to work in them. And there is one thing further Remarkable, That several pieces of *Vitriol*, which were found in the Bottom of some of those Mines, of a soft Consistence, presently, when brought up and expos'd to the open Air, grew hard, retaining several Golden Streaks in it.

But there is one thing here to be noted, which is, That, in Groves which are very deep, the Air is so unfit for Respiration, as to want a frequent Ventilation; so that the *Miners* are wont to sink an *Air-Shaft*, as they term it, some Paces off the Grove, that the Air passing from the Grove to that, by a short of Channel, or *Ventiduct*, (which *Agricola* lib. v. and vi. *de re Metallica*, calls *Cuniculus*) might keep the Internal Air in such a Temper, as to make it fit to breathe in; tho' the Mines were 200 Yards deep.

And *Agricola*, in his Book *de re Metallica*, gives further the following Account of the Course of the Air in these *Cuniculi*, or *Air-Shafts*, in these Words: *Aer autem exterior se sua sponte fundit in Cava Terra, atque cum per ea penetrare possit,*

possit, rursus evolat foras. Sed diversa Ratione hoc fieri solet; Etenim Vernis & Æstivis diebus in altiore puteum influit & per Cuniculum vel Fossam latentem permeat, ac ex humiliore effluit similiter iisdem diebus in altiore Cuniculum infunditur, ac interjecto puteo defluit in humiliorem Cuniculum atque ex eo emanat. Autumnali & Hyberno Tempore contra in Cuniculum vel Puteum humiliorem intrat & ex altiori exit: Verum ea fluxionum Aeris Mutatio in temperatis Regionibus fit in initio Veris, ac in fine Autumni; in frigidis autem, in fine Veris, & in initio Autumni: To which he adds, Sed Aer utroque tempore antequam cursum suum illum consuetum constanter teneat, plerumque quatuordecem dierum spatio crebras habet mutationes, modo in altiore Puteum vel Cuniculum influens, modo in humiliorem. And these things may give us some Reason to believe, That there are in the Earth several Periodical Changes in the Temperature of those Regions, which deserve our Consideration. But having several times enquired about these things, I am inform'd that the Air generally goes in the same way, both Winter and Summer, entering the *Air-Shaft*, and coming out of the *Perpendicular Grove*.

But to conclude this Chapter: From what hath been said, it may appear, That tho' in some Mines, the Earth seems to be distinguish'd into three Regions, yet generally the Temperature of the whole is various and uncertain: And much more uncertain is it, what is the Constitution of the Central Parts of it; and whether that be divided into Distinct Regions, or what is the State and Texture as well as Consistency of its Parts, we must be content to be ignorant of; since one of
the

the deepest Mines we have heard of, being mention'd by *Aggicula*, in his Book call'd *De Rebus Metallis*, Cap. 12. was at *Corneberg*, which exceeded not 300 Fathom; and if, according to *Gassendus*, the Semi-diameter of our Globe be 4177 Italian Miles, what a Superficial Knowledge must we have of it, who have not been able to make our Observations above 300 Fathom; and that too, in but a small Part of it's Orb.

CHAP. IV.

Of the Temperature of the Submarine Regions, as to Heat and Cold.

THE following Chapter relating to the Temper of *Submarine Regions*, I would be suppos'd to mean, by that Term, not such as are beneath the whole Ocean, but only such as are beneath its Superficies; concerning which, I shall not relate what follows, as upon my own Observation, but only as receiv'd by Information from others, who have dived into them.

Submarine
Regions
two.

And First, I shall only assign to this Element two *Regions*; the One bounded by the utmost Penetrations of the Rays of the *Sun*, and other Calorifick Causes; the other extending it self to the utmost Depth of the Water.

The Temperature of
the Upper-
most.

According to which Division it will follow, that the Upper Region must vary in it's Extent; according to the Difference of the Climate, and the Heat of the *Sun*, (supposing the Warmth of it not

not to proceed from Subterranean *Effluvia*;) and not only in the Extent, but the Temperature of that Region; which may not only be vary'd by the Influence of the *Sun*, but also, by the different Nature of the Soil about the Shores, being either *Nitrous*, or *Marchasitical*; as also by the Shallowness of the Water, which may contribute to the Warmness of it, the Rays of the *Sun* being refracted by the Subjacent Sands. To which Causes may be added the Influence of Subterranean Fire: An Observation favouring which, hath been made by *Monsieur de Ponts*, in his Voyage to *New France*; in the way to which he observ'd, That in one Place the Water was very warm, as well as the Wine, which lay in the Boat, tho' there was no sensible Alteration in the Air; and that this continu'd for three Days; whereas, on the 21st of the same Month, it was for 2 or 3 Days observ'd to be as cold.

These things in short being premis'd, concerning the Upper Region, I shall now proceed to the Lower, which is Cold; the Parts of Water being in a less violent Agitation than our Sensory: And that the Lower Region is sensibly cold, is not only consonant to Reason, but also confirm'd by the Observation of those, who have dived a considerable Depth, not only in the Northern Seas, in *Africa* and *America*; but it is also further evinc'd, by what is commonly practis'd at Sea, *viz.* to let down Bottles of Wine into the Sea all Night; which, by being immers'd in the Water, will acquire a considerable Degree of Coldness. And I am also inform'd by an Observing Traveller, that having let down about 400 Fathom of Line, with about 30 pound of

The Temperature of the Lower Region.

R

Lead

Lead at it, thirty five Degrees North Latitude beyond the Line; the Lead, when drawn up, was as cold as Ice.

From which Instances it appears, that the Air and Water so far agree, that the Parts of them being put into Motion, by External Causes, they acquir'd each a considerable Degree of Warmth; but, being remov'd and separate from those Causes, put on a contrary Quality; so that the Air and Water seem chiefly in this respect to differ, viz. in their inverted Order.

But further: From what hath been deliver'd, it appears, That tho' the Submarine Regions be sensibly colder, the nearer the Bottom; yet their coldest Region does not, by any of the aforementioned *Phænomena*, appear to be the *Summer Frigidum*, for tho' I have several times frozen Salt-water, yet it does not appear, that there is the least Ice generated in the Bottom of the Sea; since from the Bottom of the great Ocean 35 Degrees South Latitude, Gray Sand hath been brought up, where the Water was no less than two hundred and twenty Fathom deep: But yet there is one Caution to be added, which makes this Observation the less to be rely'd on; which is, That one Reason why no Ice is to be found in the Bottom of the Sea, may be the Unaptitude of Salt-Water, more than of Fresh, to be congeal'd; it requiring a much greater degree of Cold to freeze Salt-Water, than Fresh.

CHAP. V.

Relations about the Bottom of the Sea.

THAT the Bottom of the Sea is usually Salt and Cold, is a very common Observation; but being desirous to be more nicely inform'd, about what occurs in that Region; I have been told by several, who have in long Voyages, fathom'd in several places, that the Bottom of the Sea is rough, with considerable Inequalities, and Precipices; so that in a small Space a little Depth of the Sea hath increas'd to a hundred Fathom, and decreas'd as suddenly: There being likewise found several other Inequalities and Hills, observ'd in Places about 30 or 20 Fathom deep; where a Line of 16 Fathom, would upon the next Cast require 35 or 40 to reach to the Bottom of the Sea; and the like Observations I have receiv'd from several Experienc'd Mariners: Amongst which, I transcrib'd the following Account, from some Notes left in England, by one who had made a Voyage to the East-Indies: The Account was this.

The Bottom of the Sea very rough and Unequal.

February 12. After our Observation, seeing the Ground under us, we heaved the Lead, and had but 19 Fathom Rocky Ground, then haul'd by N.N.E. the Wind at N.W. and found our Water to shoal from 19 to 10 and 8 Fathom; hard Coral Ground; then suddenly deepned again from 8 to 20 and 22 Fathom Sandy Ground; and then suddenly saw Rocks under us, where

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‘we had but 7 Fathom, and the next Cast 14
 ‘Fathom again; and so having run N. N. E.
 ‘from 6 in the Morning, till 12 at Noon, about
 ‘19 Miles we deepned our Water from 16 to 25,
 ‘and the next Cast no Ground with 35 Fathom
 ‘of Line.

The Gravi-
 tation of the
 Water.

But besides the Inequalities to be taken No-
 tice of at the Bottom of the Sea, there are several
 other Things to be observ’d; amongst which
 the *Gravitation* of the Water, is remarkable; and
 tho’ it be disputed amongst *Philosophers*, whether
 there be such *Gravitation* or not; yet that there
 is, appears from several Experiments.

And First, If a Glass-Cylinder, with one End
 open, be immerg’d in a Glass-Vessel, it may be
 observ’d, That as the Cylinder is press’d lower,
 the Air by the Pressure of the Water, will be
 squeez’d higher and higher, the water rising gra-
 dually below it in the Cylinder. And the like hath
 been observ’d by several Persons, who have dived
 in a Diving-Bell, not only in the Northern Sea,
 but upon the Coast of *Africa*; where as the
 Bell went deeper and deeper, the Air became
 more compress’d, and the Water accordingly
 rose higher and higher in the Bell. And some-
 times the Pressure hath been observ’d to be so
 powerful, that I have been inform’d by one who
 let down a Glass-Vial into the Sea, near the
 Straight’s Mouth, that, having let it sink about
 40 Fathom, it was burst in pieces, by the out-
 ward Pressure of the Water; to which he added,
 That, having let down an *Aolipile* of Metal,
 and sunk it about 60 Fathom, he observ’d when
 it was drawn up, that the sides were in several
 places bruis’d and compress’d by the violent Pres-
 sure of the Water.

AN-

Another thing observable in the Bottom of The Bottom of the Sea the Sea, is, That tho' the Violence of Storms not disturb- ed in Storms may disturb it, where it is shallow; yet where it is considerably deep, the nearer the Bottom, the more calm and undisturb'd it is. And this hath been confirm'd by the Observations of Divers, who have taken Notice, That tho' the Waves were six or seven foot high, yet, at fifteen Fathom deep, the Water was very little disturb'd, only the Mud was rais'd, which made the Water dark; and what is very remarkable, is, that the Person that dived inform'd me, that having stay'd a considerable depth for some time, he found, when he came up again, a Tempestuous Storm, which had risen when he was in the Water, without being taken Notice of by him below. And the like hath been observ'd, near the shoar of *Manar*, in the *East-Indies*, where they dive for *Coral*, in a Sea, that lies betwixt the Island of *Ceylon*, and the Cape of *Comori*, which is usually very much disturb'd; inasmuch as it lies near the *Indian Ocean*, and the Gulf of *Bengala*, formerly call'd *Sinus Gangeticus*. And it hath elsewhere been observ'd, That, in considerable Storms, the Seas have not been disturb'd over the Depth of 4 Fathom.

And to these Observations I might add, had The Water at the Bottom of the Sea almost stagnates. I sufficient Evidence to build upon, That, having enquir'd, whether upon Ebbing and Flowing of Tides, the Motion of the Water was continu'd to the Bottom; I have been told by some, that it does almost stagnate, and by others, that the Current of the Water above, is different from the Tendency of that below. But not to rely upon these Relations, I have been inform'd,

by a Person who made his Observations beyond the *Cape of Good Hope*, in the Southern Sea, that, having let down his Plummet, about an hundred Fathom, he found, that the Plummet being suspended in the standing Water, made the Boat turn to the Tide, as if it lay at Anchor. And that there is such a Stagnation of Water at the Bottom of the Sea, hath been likewise confirm'd to me, by Observations made near the *Coral Fishery*, in the *East-Indies*.

CHAP. VI.

Further Relations about the Bottom of the Sea.

THAT the *Air*, is not only necessary to the Preservation of Animals, but also promotes *Vegetation*, and the Growth of Plants, I have elsewhere observ'd; but since several Trees and Plants are observ'd to grow under Water, I shall further observe what Informations I have receiv'd concerning them.

Observations relating to Coral.

And First, To what hath elsewhere been deliver'd concerning the Growth of *Coral* under Water, I shall add, That I am inform'd by one, that saw it near *Algiers*, that *Coral*, when first taken up, is not only soft and flexible, but very pale; yet when the Bark is taken off, and it is expos'd to the *Air*, it's Natural Redness presently appears. To which he added, That having

having broke several Pieces, he found it much paler within than on the outside; and that there were several black Knobs on the extream Parts of the Twigs; the place from whence this *Coral* was taken, being about nine or ten Fathom deep. And I have been further inform'd by one that sail'd to the *East-Indies*, that upon a certain sort of *Coral* he hath observ'd, certain round Berries of a very pleasant Colour.

To these Relations I shall add, That Divers ^{Trees under} have not only observ'd Trees to grow under Water, near *Manar*, which bore Leaves like those of a *Laurel*, but that not far from the Coast of *Mosambique*, in *Africa*, several Trees are observ'd to grow under Water, whose Fruit and Leaves are like those of the Tree in *America*, which bears a Fruit call'd *Acayu*.

But an Observation more Valuable, is concerning the *Maldivian* Nut, call'd *Coco*, which by experienc'd Divers, are found to be the Fruit of a Tree, which grows at the Bottom of the Sea, which are either gather'd by the Divers, or torn off by the violent Agitation of the Water; In which Fruit it was observ'd, that, whilst it was under Water, it was very soft; but when it had been expos'd a considerable time to the Air, it became very hard.

CHAP. VII.

Observations and Experiments about the Saltneſs of the SEA.

*The Inva-
lidity of the
Cause af-
ſigned by
the Peripa-
teticks.*

THE Saltneſs of the Sea, by ſeveral Peripateticks, hath been judged to proceed from the Influence of the Beams of the Sun upon the Water; but with what little reaſon may eaſily appear from thoſe ſtanding Lakes and Ponds, whoſe Water, notwithstanding the Influence of the Sun, continues freſh: And that it neither proceeds from the Influence of the Sun, nor any other external Heat may be argued, ſince though ſome freſh Water be drawn off by Diſtillation, and conſequently undergoes as great a Degree of Heat, as it can be ſuppoſed to do from the Sun Beams, it yields not ſo much Salt as is to be found in ſome Water, never expoſed to ſuch Heat; which Salt differs very little from Sea Salt, only that it is whiter, being more clear of it's ſeces, and free from a Mixture of earthy Parts.

And though ſome alledg in favour of *Ariſto-
tle's* Doctrin, That *Scaliger* affirms the Sea Water to be ſalt-eſt in it's upper Region; yet it will appear, by comparing the Saltneſs of the ſuperficial Parts of the Sea with the bottom, that the Obſervation was ill made, and does not generally hold; neither will it favour his Doctrin, ſhould it be alledged, that Sea Salt diſſolved in Water, otherwiſe than common Salt, chriſtalizes at the Top of the evaporated Solution; for conſidering how much Salt Water muſt be impregnated with;

with; and that the Quantity of Salt in Sea Water hath been observed by a *Dutch* Geographer to be only as One to Forty; it's Disposition to crystallize can be no Argument of the swimming of Sea-Salt more on the top of the Water than the other Region.

The proportion of Salt to Water.

But though I differ in this Point from the Peripatetick Philosophers; yet I do not believe, on the contrary, with some, that the Gravity of Salt makes them sink the more to the bottom; since the intestine Agitation of the Parts of the Water continually shifting Places must consequently carry it along with them; which Consideration joyned with another, which is, that I have not usually observed, Metalline Tinctures stronger at the top than bottom, might perhaps give a suspicion to some, that the present Argument is less cogent, notwithstanding the specific Gravity, betwixt Metals and their Menstruums does much exceed that betwixt Salt and Water.

But further in behalf of the Peripatetick Doctrine, it is urged out of *Linscotten*, that, at *Goa* in *Portugal*, it is usual for their Slaves to dive, and fetch fresh Water from the bottom of the Sea; but tho' this Matter of Fact were true, yet no general Rules could be drawn thence; because Experience tells us, that in other Places it is contrary. Besides it might be probably guessed, that, were it true, that fresh Water might rise by certain Springs covered over with Sea Water, as well as that several Springs in other Places should be under Water upon the flowing of the Sea: And that there may be such Springs is so far probable, that the curious *Hungarian* Governor *de admirandis Hungariae Aquis*, lays, That in the

Springs in the Bottoms of the Sea.

the River *Vagus*, near the Fortrefs *Galgerium*, Veins of hot Water rise up in the very bottom of the Water; his Words are these, *Neq; in Ripa tantum oriuuntur calida, sed etiam intra amnem, si fandum ejus pedibus suffodias; calent autem immodice*, &c. And the like hath been observed upon the *Neapolitan Coast*.

But not to urge these Relations, I shall intimate briefly, That an ingenious Acquaintance of mine, who lives in that City, hath informed me, that that fresh Water is not fetch'd so deep as to be suspected to rise from such Springs; but that it is rather the fresh Water which runs into the Sea from a River not far off, before it is mixed with the Salt Water; which Conjecture I rather believe, because near Mouths of Rivers it hath elsewhere been observed, that fresh Water hath for some time floated together, without being perfectly mixed with the other Stream.

And as for *Scaliger's* Opinion, it might be urged against it, that by a Vessel so artificially contrived, that it might be opened at the bottom of the Sea to take in Water, the Water drawn up hath been found to be Salt. But since it may be urged against this, that the Salt Water being heavier than the fresh, as it was drawing up might be mixed with it, by pressing into the Vessel; I shall add Instances not lyable to such Objections; for it hath been observed, not only at the *Cape of Comori*, but elsewhere, by Divers, that the Water is as Salt at the bottom as at the top; and I am informed, that Divers have not only under the Torrid Zone observed the Water exceeding Salt, but have brought several Lumps of Salt from the bottom with the Sea:

And

And the like Saltness of the bottom of the Sea hath been discovered near the Straights of Gibraltar's Mouth: And further, that I might not only be sure, that the Sea was thus Salt at the bottom, I procured two Quarts of Sea Water, the one taken up at the bottom of the Sea and another at the top; in which, though there was some Difference in Colour; yet being Hydrostatically tryed, there was no sensible difference in the specifick Gravity of them.

But to make out what I have before intimated, viz. That the Freshness of the Water in the bottom of the Sea near *Goa* might be produced by the Rise of some Springs under Water; though it may be objected, that the specifick Gravity of the Salt Water, would in some measure obstruct the Rising of fresh Water: Yet this Objection will easily be answered, if we consider, that according to what we have delivered in our Hydrostatical Paradoxes, and also what *Stevinus* hath observed, let the Quantity of Water be never so great, no more can resist the Rising of such Springs, but that Pillar of Water which lyes over them in a perpendicular Line; and if the Spring takes it's Rise from some high Place, so that the Weight of that Water which lyes in the Vein, be heavier than the perpendicular Pillar of Sea Water, the Rising of it can by no means be hindered by the Pressure of that incumbent Water.

But to explain and confirm this Paradox, I shall add, that having procured a long Glass Syphon, part of it being inverted so as to form a short Leg, I filled it with *Claret*, stopping the Orifice of the longer Leg with my Thumb, which Syphon,

the River *Vagus*, near the Fortrefs *Galgerium*, Veins of hot Water rise up in the very bottom of the Water; his Words are these, *Neq; in Ripa tantum eruantur calida, sed etiam intra amnem, si fundum ejus pedibus suffodias; calent autem immodica, &c.* And the like hath been observed upon the *Neapolitan Coast*.

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And as for *Scaliger's* Opinion, it might be urged against it, that by a Vessel so artificially contrived, that it might be opened at the bottom of the Sea to take in Water, the Water drawn up hath been found to be Salt. But since it may be urged against this, that the Salt Water being heavier than the fresh, as it was drawing up might be mixed with it, by pressing into the Vessel; I shall add Instances not lyable to such Objections; for it hath been observed, not only at the *Cape of Comori*, but elsewhere, by Divers, that the Water is as Salt at the bottom as at the top; and I am informed, that Divers have not only under the Torrid Zone observed the Water exceeding Salt, but have brought several Lumps of Salt from the bottom with the Sea: And

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But to make out what I have before intimated, viz. That the Freshnefs of the Water in the bottom of the Sea near *Genoa* might be produced by the Rife of fome Springs under Water; though it may be objected, that the fpecifick Gravity of the Salt Water, would in fome meafure obftruct the Riling of fresh Water: Yet this Objection will eafily be answered, if we confider, that according to what we have delivered in our Hydroftatical Paradoxes, and alfo what *Stevinus* hath obferved, let the Quantity of Water be never fo great, no more can refift the Riling of fuch Springs, but that Pillar of Water which lyes over them in a perpendicular Line; and if the Spring takes it's Rife from fome high Place, fo that the Weight of that Water which lyes in the Vein, be heavier than the perpendicular Pillar of Sea Water, the Riling of it can by no means be hindered by the Prefsure of that incumbent Water.

But to explain and confirm this Paradox, I fhall add, that having procured a long Glafs Syphon, part of it being inverted fo as to form a fhort Leg, I filled it with *Claret*, ftopping the Orifice of the longer Leg with my Thumb, which Syphon,

phon, being immerfed in Salt Water contained in a Glafs Veffel, and the Orifice of the longer Leg being opened, the Claret, notwithstanding the Prefure of the Salt Water, prefently rofe up in it in the Form of Clouds, which lafted till the Liquor in the Pipe was brought to a juft *Equilibrium* with the incumbent Pillar of Salt Water.

*The Reafon
of the Salt-
nefs of the
Sea.*

But to pafs on to the Cause of the Saltnefs of Sea VVater, I deny not what *Gaffendus* and other Moderns teach; but grant, that the Saltnefs proceeds from a Solution of Salt in the VVater; yet I am apt to fufpect, that that Saltnefs is not only fupplied by thofe Salt Rocks, which may be contiguous to, or near the Water; but that the Sea is in a great Meafure fupply'd, by Salt wash'd away and carry'd into it, by Springs and Rain-water, which float into the Ocean. And I am the more confirm'd in this Suspicion, becaufe feveral Chymifts have not only found Salt in fome Waters; but have obtain'd a good Quantity of common Salt upon refining of Salt-Petre, which according to Sir *Francis Bacon*, is in moft Soils, which are not fpent in Vegetation, or wash'd and confum'd by the Sun and Rain.

But not to infift too long on thefe things, it is not only probable, That the Salts in the Earth, may, by this Means, contribute to the Saltnefs of the Sea; but that, from what hath been before deliver'd, fuch Salts may be communicated to it by latent Springs, not to be taken notice of or discern'd by us. And further, That fuch Salt as abounds in the Earth, may fupply the Sea with moft of the Salt which is perceiv'd to be in it; we are to render it further probable,

to

to consider, That the Sea-Salt, and that, are agreeable in the main, with each other; since they have almost the same Shape and Taste, &c. the former of which will appear by Evaporation and Crystallizing them; and as for some small Difference to be perceiv'd betwixt them, that may easily arise from those Bituminous and other, as well as Nitrous Bodies, which flow into the Sea, and which may be mixed with them, both by the internal Agitation of the Parts of the Water, as well as the outward Action of the Sun and Air.

And that there is such Salt dissolv'd in Sea-Water, might be probable, if it were possible so to raise the fresh Water it was dissolv'd in, by Distillation, as to leave the Saline Parts behind; but not now to mention, that not only I, but the Judicious Sir *John Hawkins*, in his Voyage to the *East-Indies*, have, by distilling of Salt-Water, obtain'd from it a wholesome fresh Water; I shall, without making a long Digression, proceed to answer an Objection, which is urg'd against what I have deliver'd, viz. That if the Springs acquir'd such a Saltiness by running through the Earth, it would be discernible before they emptied themselves into the Ocean. To this I shall answer, That besides those fresh Springs which are visible to us, there may be several others which lye too deep for us to take Notice of: But here it may be requisite to take Notice, That I do not say, That the Saltiness of the Sea wholly depends on such Supplies; but that they contribute to the Saltiness of it.

Having

The Bitter-
neſs of Sea
Water,
thence.

Having ſaid ſo much of the Saltneſs of the Sea and its Cauſes; It may be now ſeaſonable to obſerve, from whence proceeds that Bitterneſs remarkable in ſome, if not moſt Sea-Water; which, we conceive, may proceed, partly from the external Power of ſome Catholick Agent, and partly, from thoſe Bituminous Bodies which are carried along with Spring-Water into the Sea, which hath been viſibly apparent in the Iſland *Barbadoes*, where that which they call *Barbadoes Tarr*, hath been ſeen to flow from the Rock into the Sea; and to theſe Cauſes may concur ſome Subterranean Exhalations and Effluvia, which I have elſewhere taken notice of to flow from and pervade the Earth. And as for thoſe different Taſtes which are perceiv'd in the Sea at ſeveral Places, it is no leſs probable, that they proceed from other adventitious Bodies mix'd and incorporated with the Sea-Water; for that the Sea-Salt which is diſſolv'd in it, is not a ſimple Salt, but a compound, I have been induc'd to believe by a Salt which I obtain'd from it.

And that ſome Catholick Agents may work Changes in the Saltneſs of the Sea, which it would not otherwiſe have, by a bare Solution of thoſe adventitious Bodies that are mix'd in it, I have Reaſon to believe, ſince I have found, That by keeping the Parts of Sea-Water in Agitation, by a continued digeſtive Heat, it hath conſiderably differ'd in Taſte, from a bare Solution of Sea-Salt in Water. And for a further Confirmation, That the Saltneſs of the Sea is vary'd in ſeveral Places, I ſhall barely intimate thoſe ſeveral Colours, different Qualities, and ſtupendious

pendious Multitudes of adventitious Corpuf-
cles which are mix'd with it.

But to proceed, amongst the various Obser-
vations to be made about Sea-Water, it is
worth our Notice, That if it be kept from A-
gitation, it will in a short time stink; which I
have not only observ'd, by keeping some of it
in a Runlet for some time; but also, I am in-
form'd by one, who, in a Voyage, was for
some days becalmed, that the Sea, for want of
Agitation, stunk so much in twelve or fourteen
days, that the Smell was almost intolerable;
which continued till the Winds put the Water
into Agitation. Which agrees with what Sir
John Hawkins hath observ'd, who relates the
following Story: *Were it not for the Moving of the
Sea, by the Force of Winds, Tides and Currents,
it would corrupt all the World. The Experience of
which I saw Anno 1590, lying with a Fleet about
the Islands of AZORES, almost Six Months, the
greatest Part of the time we were becalmed, with
which all the Sea became so replenished with several
sorts of Gellies, and Forms of Serpents, Adders
and Snakes, as seem'd Wonderful; some green,
some black, some yellow, some white, some of diverse
Colours, and many of them had Life, and some
there were a Yard and a half, and some two Yards
long; which had I not seen, I could hardly have be-
liev'd; and heretofore were Witnesses all the Company of
the Ships, which were then present, so that hardly a
Man could draw a Bucket of Water clear of some
Corruption. In which Voyage toward the End there-
of, many of every Ship fell sick of this Disease, and
dy'd apace, but that the speedy Passage into our own
Country*

*Agitation
 requisite to
 preserve Sea
 Water from
 stinking.*

*...
...
...*

The Saltneſs
of the Sea
differs.

Country was a Remedy to the Crazy'd, and a Preſervative for thoſe that were not touch'd.

As for the different Degrees of the Saltneſs of the Sea, I ſhall deliver what I have been inform'd of, as briefly as I can. And *Fiſt*; It hath been obſerv'd, by one to whom I gave a Glaſs conveniently ſhap'd to try the ſpecifick Gravity of the Water, that it grew heavier and heavier as he came nearer the Line, till within about thirty Degrees Latitude; from whence to *Jamaica* he obſerv'd no Alteration in the ſpecifick Gravity in the leaſt. And in Confirmation of this I am likewiſe inform'd, by one, who for his own Satisfaction weigh'd the Water, both under the *Equinoctial* and at *Cape of good Hope*, and found that the Weight of both was the ſame. To which may be added that it is commonly obſerv'd at *Adofambique*, one of the hotteſt Places in the World, that the Sea is ſo ſalt there, that it bears up the Ships a conſiderable Height out of the Water, more than in other Places; and that the Water may be much ſalter in one Place than another, by having more Salt diſſolved in it, does not only appear from what hath been ſaid, but alſo from what is frequently obſerv'd in the different Strength of Brine-Pits.

But to paſs from what I have learnt by Information, to what I have obſerv'd my ſelf concerning the Proportion of Salt to the Water it was diſſolv'd in, which I have obſerv'd in Sea-Water, betwixt *England* and *France*.

The Proportion
of Salt
in Sea-Water.

The firſt Experiment I made to diſcover the Quantity of Salt was this, that having, in a Vial, weigh'd an equal Proportion of Sea-Water taken up at the Surface of the Sea, with com-

mon Water, the Weight of the former exceeded the latter a forty fifth Part; but these Liquors being more Hydrostatically try'd, by weighing Sulphur in them, that which in the Sea-Water weigh'd $3\text{lb} + 10\frac{1}{2}\text{ gr.}$ in Sea-Water, fetch'd from the bottom, ballanced the same Weight; but being weigh'd in common Water, it weigh'd $3\text{lb} + 15\frac{1}{2}\text{ gr.}$ so that the Sea-Water was a Fifty third Part heavier than the fresh; the Difference in which way of trying it, from what was observ'd in the former Tryal, I could attribute to nothing, but some grosser Saline Parts mix'd with the common Water, or some evaporated Parts of the Sea-Water.

Another way we made use of to try the different Specifick Gravity of these Liquors, was, by Distillation *Ad Siccitatem* in a digestive Furnace, in which a Pound *Averdupoise* Weight yielded $3\text{lb} 10\text{ gr.}$ of Salt; so that the Proportion of the Salt to the Water was as 30 and $\frac{1}{2}$ to one, being near the Thirtieth Part.

But suspecting that the Quantity of this Salt was much increas'd by imbibing Moisture from the Air, I caus'd it to be dry'd in a Crucible, and found it weigh'd $3\text{liij} + \text{ss}$, which is about a Thirty sixth Part.

How so much a greater Quantity of Salt should be obtain'd by Distillation, is difficult to conjecture; yet I am apt to think, that it might proceed from some Parts of the Water detain'd from flying away, by being enclos'd amongst the cubical Salts; and this I am apter to believe, because I have elsewhere prepar'd a Salt, which would coagulate and embody it self with

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Water;

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S
Water;

Water; and *Secondly*, Because I am told, That a Sort of Salt is brought from the Coast of *Spain*, which being here purify'd and dissolv'd, will yield a double Quantity.

The Sea-Water salt-er sometimes than others.

Whether the Sea-Water may at some times be more impregnated with Saline Parts than at others, I conceive probable, if we consider the Supplies that it receives both from the Earth, which are carry'd to it along with Springs, and also, the sudden Additions it may receive from Subterranean Exhalations; but these Observations being very nice, it most commonly requires other Measures than what *Hydrostaticks* afford; for it may be observ'd, That several volatile Salts which are of no considerable Weight above common Water, may be mix'd with it without being perceiv'd; so that one may easily be deceiv'd in judging of the Saltnefs of the Sea altogether by *Hydrostaticks*; because, that which violently affects the Taste, may have but a small Influence in the Balance: To confirm which I shall add, That a Bubble of Glass, having Metal in it, weigh'd 3iij + 51 gr. in Spirit of *Sal Armoniack*, and but 3iij + 45 $\frac{1}{2}$ in common Water. But further, I weigh'd in the same Liquor an equal Proportion of Sea-Salt brought from the torrid Zone and *Sal Armoniack*, and found, that the Bulk of the former was, to an equal Proportion of that Liquor, as two and a quarter to one, whereas the *Sal Armoniack* was not above a hundredth Part, above one, and $\frac{1}{2}$ to one, which is the more strange, because Part of the Composition of *Sal Armoniack* is Sea-Salt.

But that I might be satisfi'd what was the greatest Degree of Saltness, that Water would be impregnated with; I took a Lump of Salt in Water, till it would dissolve no more; and found that a Brine might be made so strong, that the Salt would be dissolv'd in five times its weight of Water.

To conclude this Discourse, I shall add one thing which hath not been taken notice of by *Hydrostaticians*; which is, the weight of the Sea-Salt to its Bulk of Water, which I have found to be almost as two to one; and I likewise found, that a piece of *Sal Gemm*, which is more pure and weighty than Sea-Salt was to its Bulk of Water about as 2 $\frac{1}{2}$ to 1.

CH A.P. VIII.

Memoirs for the Natural History of Mineral Waters.

THE Use of *Mineral Waters* are so Universal, and the Methods which some Physicians take to try them so slight; that, tho' I am satisfied it is difficult, without Experience to Ascribe Virtues to them *a priori*, by Reason of the Great Variety of *Minerals*, which may impregnate them with Particles of various and very different Natures; I cannot but think, but that if we were furnish'd with a sufficient Number of *Quarries*, and several Methods in order to a Discovery of them, more nice Tryals might

much Contribute to the clearing up of a Natural History of *Mineral Waters*; since by a competent number of Experiments it might be hoped, that the Nature of those *Metalline Salts*, with which *Mineral Waters* are Impregnated, might be discovered.

Wherefore I have lay'd down such sorts of Experiments, that might be most easily try'd, *viz.* chiefly Chymical Ones, which may be made at home, without the Inconveniencies of attending those Mineral Fountains from whence they spring.

And because my Design is rather to improve Physick by the following Observations, than to entertain Speculative Naturalists; I have chiefly made it my Business in the following Papers, to consider those Waters call'd *Acidula*, rather than the other term'd *Therma*, because the former are of more general Use.

*The danger
of an ill use
of Mineral
Waters.*

But perhaps some may think that the *Quæres* hereafter propounded may be too troublesome, and more than requisite; since the Use of *Mineral Waters* are thought so innocent, as to be of no ill Consequence if Unsuccessful. To which it may be answer'd, that tho' when skillfully given, they do a great deal of good; yet they are as prejudicial if unskillfully prescrib'd; and therefore, since there cannot be too much Caution, we cannot be too inquisitive to inform our selves of their Virtues; for there may be a great many hidden Qualities in them, and they may be impregnated with several Metalline Properties, which may not be discover'd to the Eye or by common Tryals.

Besides, were such Experiments industriously prosecuted, they might help to discover several other Qualities in *Mineral Waters*, which are as yet unknown; for from the following Experiments it is evident, that the Earth, which abounds with Minerals of a Martial Nature, may be more apt to impregnate subterranean Waters than we can otherwise imagine; for upon pouring of a Tincture of Galls filtrated through Cap-paper upon filings of Steel, the Liquor in half an hour became Opacous, and almost as black as Ink: The like *Phænomena* to which were exhibited by Steel in an Infusion of Brasil or Log-wood made in common Water. To which we may add, that several Waters have been discover'd under ground of very different Tastes; some of which have been found to be corrosive, and others as harmless, being endow'd with several Medicinal and Useful Qualities; and I am inform'd more particularly of one, which is a Mine of Coral in *Devonshire* about 360 foot deep, in which was found a Water very thick and red, yet cool and Diuretick, and not in the least nauseous to the Taste.

*The Effects
of filings of
Steel, in a
Tincture of
Galls.*

CHAP. IX.

Titles propos'd for the Natural History of Mineral Waters, consider'd whilst in their proper Channel.

Queries in order to a discovery of the Virtues of Mineral Waters.

IN order to a natural History of *Mineral Waters*, they ought to be consider'd in three different Capacities: First, as they are found in their natural Receptacles; Secondly, when drawn up for use; and thirdly, with Respect to their Effects on Human Bodies. To the first of which Heads the following *Quares* may be refer'd.

1. Within the Precinct of what Climate or Parallel, and in what degree of Latitude the *Mineral Waters* are to be found?
2. To what point these Waters lie open most in their Receptacles?
3. Whether the Ground in which they are found be a Plain, or how much it differs from a Plain?
4. If the Ground be upon an Ascent, how far they are from the bottom of that Ascent?
5. Whether a Recrementitious Substance adheres to Stones long contiguous to these Waters?
6. Whether subterranean Fires be near such Waters, and what *Phænomena* such exhibit?
7. Whether Brimstone or *Sal-Armoniack*, &c. be found about the Vents of such subterranean Fires?

8. Whe-

8. Whether instead of subterranean Fires, there are other adjacent *Estuaries*? and whether such be constant or intermitting? and if so, whether periodical or irregular?

9. Whether Mineral Fumes of particular colours or smells arise from such *Estuaries*?

10. Of what Temper the neighbouring as well as the Soil they pass through is of?

11. Whether and of what Nature those *Minerals* are of which they pass through?

12. Whether the *Mineral Waters* be originally fresh, and derive their Virtues from the Soil they afterwards pass through?

13. Whether if it acquir'd its Virtues so, there were upon the Impregnation any Effervescence? or whether any such Effect succeeded its Mixture with another Liquor?

14. Whether there be a Spring of a contrary Nature near it, viz. as to Heat and Cold, as it is observ'd in *France*.

15. Whether an oily or bituminous inflammable Substance float in it?

16. Whether the Seasons of the Year, or Temperature of the Weather alters them? and what Qualities they lose or acquire by such? For after Rain I have observ'd such Waters incapable of turning a Tincture of Galls black: But as to its Medicinal Virtues, I have found that Rain after long Droughts, hath rather increas'd than diminish'd their Strength, by dissolving and diluting those Salts, which were fix'd in the Earth for want of a Vehicle; but if the Waters be weak, and the Rain much, those Salts being the more diluted, render the Waters less Effectual.

17. Whether the Qualities of the Waters may be Chymically and Mechanically discover'd? as also of what Colour and Weight, and with what *Menstruums* their *Salts* may be mix'd? and likewise what Substances they will yield when expos'd to different Degrees of Fire, and what other Chymical Tryals those as well as the *Caps Mortuum* may undergo?

CHAP. X.

Containing Titles for the Natural History of Mineral Waters when drawn out of their Receptacles.

*A Continu-
ation of
Queries.*

1. **W**HETHER the *Mineral Water* propos'd be actually Hot or Cold? From whence we may judge from what Depth those Waters rose? and whether they were impregnated with a *Salt-Peter* or *Sal-Armoniack* in their Ascent? And the several Degrees of Heat or Cold may be either try'd by immersing a *Thermoscope*, or by trying whether they will Coagulate Oyl of Aniseeds or melt Butter?

2. Of the specifick Gravity; which, being compared with that of common Water, will shew what Quantity of *Mineral* Substance the Water hath dissolv'd in it; and whether Metalline or more Volatile, as it is heavier or lighter; where we are to observe, that *Mineral Waters* are sometimes lighter than common Water; partly, because they are impregnated with

Volatile Parts; and partly, because they are void of Saline Parts, which makes common Water something heavier. But to discover the different Weight of several Mineral Waters, I caus'd a Glass-Viol with a flat Bottom and a long Neck, three Inches long, to be blown, which was so light, as to weigh but $3vi + 42$ Grains; tho' it was capable of containing $3iij$ lb and 43 Grains of Water; which made it more proper for a Nice Ballance, by which I found the following Mineral Waters to differ thus in Weight.

Waters	Ounces	Drachms	Grains
Common	3	4	43
Common distill'd	3	4	41
Altus	3	4	48
Epsom	3	4	51
Dulwich	3	4	54
Staton	3	4	55
Barnet	3	4	52
North-Hall	3	4	50
German-Springs	3	4	40
Tunbridge	3	4	38
Mington, from the Musick-House.	3	4	36
Mington, from the Faulwich Steps.	3	4	39
Mington, from the Cellar.	3	4	39

3. Of their different Degrees of Transparency or Opacity.

4. Whether without being expos'd to the Air, it will afford a Precipitate. By which Observation

servation the different Soils through which they pass, will not only be discover'd, but hence we may learn to distinguish such from the true *Caput Mortuum* of the Water. *German Spaw Water* yielded a good Quantity of yellowish *Ox.* *N. B.* the Water so try'd must not be expos'd to the Air, for if it be the Air will precipitate a considerable Quantity of Matter in most Waters.

5. What *Microscopes* can discover in *Mineral Waters*?

N. B. those moving *Corpuscles* discernible in a Solution of Pepper, &c. in Water, are *Animalcula*, and not Portions of Inanimate Matter, which swim up and down such Liquors; which is apparent if those little Animals be touch'd with Spirit of Salt, for being kill'd by it, they move much more slowly.

6. Whether there be any variety of Colours in several *Mineral Waters*?

7. Of their different Odours. These are to be perceiv'd at the Spring-Heads, where not only a Bituminous and Sulphurious Smell may easily be perceiv'd; but I am inform'd, that there is a *Mineral Spring* in *France* which hath a manifest vinous Odour.

8. Concerning the different Tastes of *Mineral Waters*.

9. Whether taking it up, or keeping it stop'd or unstop'd? or whether freezing or thawing it will alter the Colour, Smell or Transparency of it?

For tho' some Waters retain their Purgative Virtue a good while; yet, I have observ'd an Exhalation of some fugitive Parts from those which are lighter than Water, and abound with
Spi.

Spirituons Parts; so that, tho' they were carry'd but a little way from the Fountain, they presently lost their Power of turning a Tincture of *Galls* into a Purple, and instead of that, turn'd it red; and even the Strongest *Waters*, if kept unstopp'd, or not kept close, presently lose that Property.

10. Concerning the different Consistency of such *Waters*.

11. Whether they be more apt to Expansion and Condensation, or Heat and Coldness, than Common *Water*?

12. Whether they are apt to Putrify, and how soon, and what *Phænomena* they afford?

13. What Alteration in Colours ensues the Mixture of Astringent Juices with them, as also their Mixture with several Juices of the Body.

N. B. in trying of *Mineral Waters*, it is usual to make use of a Tincture of *Galls*, without considering the Alterations which may be made in the Tryal, by an Uncertain Proportion of *Galls*: Wherefore I usually make use of a settled Proportion, as 5 Grains to an Ounce; tho' *Mineral Waters* may be try'd with much more Expedition, and Certainty, by making use of the Powder it self, suspending about three Grains of Powder in an Ounce of the *Waters*; and I have found by Experience, that so small a Quantity as a Grain, hath given *German Spaw-Water* a deep Purple Colour. But it is not always necessary to make use of *Galls* in such Tryals, since *Rose Leaves*, or the Flowers and Bark of *Pomegranates*, will have much the same Effect, affording a Cloudy and Blackish Tincture.

And

And it is further to be noted, That I made it one Part of this *Quere*, what Colours would be produc'd by a Mixture of *Mineral Waters* with Animal Juices; because I have observ'd the Root of the Tongue sometimes Blackish upon the taking of Large Doses.

But to return to what I have observ'd concerning the trying of *Mineral Waters*, by an Infusion of *Galls*; I not only doubt whether all *Martial Waters* will turn a Tincture of *Galls* black, but whether all liquors which will, are to be esteem'd *Martial*; for I have found that a *Mineral* of a Different Nature from *Steel*, would give it a Black Colour; and that a Liquor, which was a Preparation of *Steel*, would not; which induc'd me to think, that such a Tincture was rather the Effect of some *Acid Fumes*, which had work'd on the *Mars*, with which those *Mineral Waters* are Impregnated.

To which it may be added, That I have found, that if a *Vitriolate Water* be impregnated with *Copper*, instead of *Iron*, instead of turning a Tincture of *Galls* Blackish, it only would render it Muddy and Thick. And I had a sort of white Earth, which I found by Tryals to be *Lead*, that would turn a Tincture of *Galls* Blackish, tho' it was altogether void of *Martial* Parts, and probably would have very bad Effects, if taken inwardly. To which I might further add, That a Tincture of *Gold* in *Aqua fortis*, likewise turn'd an Infusion of *Galls* Black.

And those Observations I have been the willingest to lay down, because, tho' I would not be thought by them to slight the Use of *Galls*, in such Tryals, yet I would thence
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urge them to make such Tryals to be more warily made.

And because it may be of some Use to observe the different Colours exhibited by such Tryals, I shall add, the following Considerations, as Requisite to be thought on by him, who designs to make such Experiments.

Observations requisite in Try-ing Mineral Waters.

1. That he ought to observe the Changes of Colours, made by such Tinctures, in a good Light; which may help a Curious Observer to distinguish what *Minerals* such Tinctures are impregnated with. 2. It may be of Use to vary the Shades of Colours, produc'd by *Mineral Waters*, either by dropping such Waters upon Paper, whose Pores are saturated with *Vitriol* powder'd, or ting'd with a Decoction of *Log-wood*; Several Variations in Colours may be also made, by dropping other *Medicinal Liquors*, either into the *Mineral Waters*; or the Infusion of *Galls*, before Mixture, or after. 3. I would recommend, for such Tryals, not only the Parts of Astringent Plants, but also Animal, and especially *Mineral Substances*: For, besides the Astringents, I have contriv'd a certain Substance, which would not only turn a *Vitriol Water* impregnated with *Iron* black; but also One saturated with *Copper*; a *Succedaneum*, to which may be made, by adding to *Sulphur* as it melts over the Fire, an equal Proportion of *Salt of Tartar* finely powder'd, stirring them till they incorporate, and become red: Which Mixture, being put into a Glass Retort, with half it's weight of *Sal-Armoniack*, dissolv'd in Water; let it be distill'd in Sand, shifting the Receivers as the Liquor drawn off, is ting'd more or less;

less; so that the strongest may be preserv'd by it self.

And such Tryals as these will be of more use, than those usually made with a bare Tincture of *Galls*; since there are several *Mineral Substances* and other Bodies, which *Mineral Waters* may be impregnated with, which discover not themselves in an Infusion of *Galls*: As *Sulphur* or *Copper*, may be so lock'd up in these Waters, as not to be perceiv'd, till the Body of the Liquor is open'd by some proper Additament. And even *Arsenick* it self, may be so disguised, as not to be perceiv'd, when mix'd with the Waters; yet if Spirit of Urine, or Oyl of *Tartar*, per *Deliquium*, be dropp'd into a Solution of it, it presently precipitates in the Form of a white Powder; and so likewise, if a Solution of *Saltimate* be added to it. But to discover, whether *Mineral Waters* be impregnated with *Arsenick* or not, I put *Dantzick*, or *English Vitriol* into a Solution of it, either of which caus'd a dark precipitate gradually to subside.

Whether
Mineral
Waters
have Arse-
nick dissol-
ved in them

14. Whether Spirituous Acids, volatile *Alkalis*, or Lixivial Salts will precipitate such Waters?

15. The Manner of Extracting Salts from such Waters, and what Quantities may be extracted? Guessees may be made concerning the Saltness of these Waters, by trying whether they will Lather with Soap? and if not, what Quantity of Curdled Matter they will yield? I have observ'd that even the lightest Waters will yield a small Quantity of common Salt.

16. How to discover what Acidity is to be found without Evaporation. Having taken a
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peculiar Method to try the Acidity of *Mineral Waters*, by mixing them with an Infusion of *Lignum Nephriticum* in simple Water, I found, that tho' *German Spaw*, yielded a small Quantity, yet in that of Action, there was none discernible.

17. What may be observ'd by *Distillation in Balneo*?

18. What, and whether the same Quantity of *Caput Mortuum*, be afforded by *Evaporation*, and *Distillation*?

19. Whether *Mineral Waters* will acquire the same Qualities and Texture, by a Reunion of their *Caput Mortuum*, when distill'd to such a Consistence, in *Glass-Vessels* exactly luted, which they had before?

20. What Changes, if any, *Mineral Waters* undergo by being boil'd in Water, in a *Glass* *Hermetically* seal'd? From whence might be learn'd whether a Change of Qualities would succeed an Alteration of Texture, without a manifest loss of Parts? And whether an Agitation of Parts, without the Influence of the Air, would precipitate any thing, or deprive it of it's Power to turn a Tincture of *Galls* Purple?

21. How much the *Mineral Waters* exceed their *Caput Mortuum* in Proportion?

22. What Parts are contain'd in the *Caput Mortuum*, and whether dissoluble in Water?

23. How much the *Saline* and *Terrestrial* Parts differ in Proportion?

24. Whether in strong Fires, the *Salts* be Volatile or Fix'd, and to what Degree?

25. Whether the *Salts* will *Crystallize per se*,
or

or with other *Salts*, and what's the Figure of the *Gemine*, or *Compound'd Crystals*?

26. Whether *Acid* or *Alkaline* Qualities are most predominant? The *Acidity* will either appear to the Taste or Smell; or may be discover'd by turning *Syrup* of *Violets* red; as also, by making use of an Infusion of *Lignum Nephriticum*, which upon a Mixture of *Acids* loses it's Blue Colour: Their *Acidity* may likewise be discover'd by trying, whether they will be precipitated by *Alkalis*, or ferment with them. And if *Alkaly* be predominant, it, on the contrary discovers it self by a Lixivial Taste and Smell; and may be discover'd, by turning *Syrup* of *Violets* Green, or precipitating a Solution of *Sublimat*, or Fermenting with *Aqua fortis*; or lastly, by increasing the Colour of a Tincture of *Brasil* or *Lag-wood* in Common-water? And tho' we have no such Springs here in *England*; as afford *Alkaline Salts*; yet without question, in *Egypt* such may be found, since their *Latron*, or the *Egyptian Nitre*, abounds with a *Salt* of an *Alkaline* Nature: and I have obtain'd such an *Alkaly* from that Famous *Water* of *Bourbon* in *France*, which would turn *Syrup* of *Violets* green, and ferment with *Volatile Acids*. If such *Waters* abound with *Vitriol*, they'll turn an Infusion of *Gall* black, and Vomit those that drink them; and, if an *Alkaly* be added, will yield a yellow Precipitate, upon dropping of *Spirit* of *Urine*, or *Salt* of *Tartar* into them.

I have not found any of the *Waters* about *London*, to be impregnated with *Vitriol*; and I am told, that in *France* the *Mineral Waters* are so far from being impregnated with *Vitriol*, that there is

not

a *Vitriolous* Spring in that Kingdom. As for the Nature of the Salt, which most *Mineral Waters* are impregnated with, I think that it is not to be referr'd to any Glass, but is either *sui generis*, and a peculiar one, or a Compound Salt, made up of such as the *Water* is impregnated with, in it's Passage through the Earth; and that Purgative Salts may, by a Change of Texture, be made of *Salts* not at all Purgative, I the rather believe, because I have been told by an Ingenious *Emperick*, That a *Salt* which I made of Salt of *Tartar*, and Common *Sulphur* mix'd together, had a gentle Purgive Virtue.

27. In what *Menstruums* the *Caput Mortuum* may be dissolv'd? and in what it may not? Whether Volatile or Fixt, and what Qualities it hath in Respect of Colour or Smell?

It is to be admir'd, what a great deal of *Caput Mortuum* some *Mineral Waters* yield in Comparison of others; since those *Waters*, which are purely *Diuretick* have very little, if compared with the *Caput Mortuum* of Purgive *Waters*: For tho' a pound of *Barnet Waters*, yielded a Drachm, yet the same weight of *Tunbridge* afforded but a Grain. And,

It is not a little strange, that so small a Quantity of a *Mineral* should impregnate so much *Water*, as I have, by Tryal, found a Grain of *Iron Stone* did, enabling it to Tincture an Infusion of *Galls*, deeper than *Tunbridge* or *German Spaw Water* would. And I have try'd, that half a Grain of *Marchasite*, dissolv'd in Spirit of *Nitre*, communicated a Tincture to 61440 Parts of *Water*; tho' Part of that *Marchasite* was *Sulphur*, and Part of it *Caput Mortuum*.

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And here it may be seasonable to take notice, That if so small a Portion of a Metalline Substance would, when grossly dissolv'd, impregnate so large a Quantity of *Water*; how much more may it, when rais'd in the Form of a Subtile *Mineral Fume*? and as in such a Form, it may impregnate a larger Quantity of *Water*, so will it be more apt to fly away, when expos'd to the Air. And that *Vitriol* may probably rise in the Form of a Vapour, without losing it's Qualities, is evident in *Sublimate*, which consists of *Mercury*, chang'd by an Addition of *Salt* and *Vitriol*; for some *Vitriolick* Parts being carry'd up in the Preparation, turn *Opacons* upon an Affusion of Spirit of *Sulphur*.

But further, to make it evident, that the Particles of *Iron* may be considerably expanded, I dropp'd four Drops of a *Vitriolick* Liquor, made use of in *Copperas-works*, into twelve Ounces and a half of *Water*, and found, that it so much impregnated 1500 times it's Proportion of Common *Water*, as to make it strong enough to turn a Tincture of *Galls Purple*, tho' by Evaporation we found that 3 Parts of 4 of that Liquor were *Water*.

28. What Alterations the Earthy Parts of *Mineral Waters* undergo by *Ignition*; and whether they may be *Vitrify'd per se*? as also what Colours they impart to *Venice Glass*, if mix'd with the Powder before Fluxion?

29. Of what use they are in Baking, Brewing, Tanning, or Dying of Colours, &c.

30. How many ways they may be made Artificially, and with what Proportion of Ingredients?

CHAP. XI.

Titles for the Natural History of Mineral-Waters, consider'd as a Medicine.

IT may be worth Observing, in order to a more Compleat *Natural History* of *Mineral-Waters*, what Constitutions they agree with, and in what Distempers they are Proper or Dangerous: What Sensible Operations they have; and whether their Effects be alter'd by Drinking them Hot or Cold; at the Well, or at a Distance from it: Whether Exercise, or the Warmth of a Bed, promotes their Operation: Whether they have any Occult Qualities.

It may likewise be requisite to observe; What good Effects may succeed a due Preparation of the Body that drinks them, and what Advantage it may be to drop some Strengthening Stomachick into the First Dose: What Quantity is enough for the First Dose, and how it must be vary'd: How long they may be Drunk, and whether constantly, or with Intervals; whether Purging sometimes may contribute to their good Effects: What Regimen in the Six *Non-Naturals* is to be observ'd, whilst they are a-taking: Which are the Signs that denote the kindly Operations of them; or their future ill Effects. What ill Accidents attend the taking of them, and how they may be Remedy'd, or Prevented. Whether it be proper to Purge after the Taking of them.

What Effects they will have by Mixing other Liquors with them; or, by Boiling Meat in them; Whether a *Salt* extracted will be of Equal Effect, when Diluted in Fresh *Water*. What External Effects they will have, and of what use their Sediment is when Externally apply'd: What Effects they will have on *Dogs*, if injected into their Veins, or if they be kept with such for constant Drink.

CHAP. XII.

Of the Natural and Preternatural States of Bodies; especially the Air.

IT is the General Consent of most Men, that the Determinate States of Bodies are not only first fram'd by what they call *Nature*; but that they are likewise preserv'd in those States, by the Superintendency of that Power; and that whenever they lose that State, they are said to be put into a Preternatural One. But if we consider, that such Changes proceed from Natural Causes, and that those New States depend on the like *Catholick* Agents, and the Establish'd Laws of Nature; it will appear, That the Distinction Men usually make betwixt the *Natural* and *Preternatural* States of Bodies, is but ill-grounded; and that *Preternatural*, is only a Relative Term, intimating that that Body hath undergone a Change, either by the Operation of some unheeded or more noted Agent. For

Matter

The Common Distinction betwixt Natural and Preternatural States is ill grounded.

Matter being altogether void of Sense and Perception, and not affecting one State more than another, the Changes it undergoes, depend on the Alteration of it's Textures, and New Position of it's Parts, alter'd afresh, by that Agent, which such a Body was last expos'd to. As a piece of *Wax*, is put into a New Form, by the last Impression, made by another Body upon it, without affecting one Form more than another it self.

And that the States of some Bodies, which are said to be *Preternatural*, as truly depend on Natural Causes, and the Establish'd Laws of Nature as others, is evident in *Ice* and *Water*: In which Bodies, the Forms of each depend upon the Effects of External Agents; for, tho' in these Hotter Climates *Water* is Esteem'd a Natural, and *Ice* a *Preternatural* State of that Substance; yet I am inform'd, that in *Siberia*, a Province belonging to a *Russian* Emperour, *Water* is froze most part of the Year; and at a small Depth, from the Surface of the Earth, the Soil is froze throughout; where *Ice* is look'd upon to be the Natural, and the Alterations made by a Thaw, and the Influence of the External Temperature of the *Air*, and the *Sun* Beams, are esteem'd *Preternatural* States of Bodies. And farther, tho' *Butter* in our Clime be sold in a consistent Form, and when it is melted, is look'd upon to be in a *Preternatural* State; yet I am inform'd, that amongst the *Europeans* it is fluid, and is sold by Measure, and not by Weight, as here in *England*. And it is further observ'd, That several Substances, as *Rosin of Jalap*, *Gum Lacca*, and even

Ice a Natural State
in some Places.

Aloes it self, are considerably softened in their Consistence, by the Temperature of the *Air*, and the Force of External Heat, whilst they pass under the *Torrid Zone*; so that I am told, that the former of the aforementioned Drugs was melted into a sort of *Balsam*, whilst it continued in *Africa*, but when it was brought to *Spain*, it put on a Consistent Form again: And tho' *Aloes* was soft whilst carry'd through *America*, and those hotter Climates, yet when it approach'd our Climate, it presently became hard.

But to bring further Instances concerning the *Natural* and *Preternatural* States of Bodies, I shall observe, That according the Receiv'd Notion of *Natural* and *Preternatural* States, it is very difficult to determine the Natural State of the *Air*; for, not to insist on the different Temperature of the *Air*, as to Heat and Cold, in different Climes; It may be demanded, Since Heat and Cold, rarify and expand the *Air*, what is to be esteem'd the Natural State of it, in Reference to Rarity and Density? And it is no less Questionable, what Place is most fit to determine it's Natural State, since the State of it is not only different in several Countries; but in those Places at different Times; And that the Changes, as to the Density or Rarity of the *Air*, are very frequent, appears by the several Degrees of the *Atmosphere's* Gravity, evident in the *Torresellian* Experiments, hereafter to be deliver'd.

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State, the
Natural
State of the
Air.

But further: Except the States of the *Air* be said to be *Preternatural*, only in a Relative Sense, with respect to the State it was in, before it under-

underwent the last Change, it is not impossible to make it out, That the *Air* is always in a *Preternatural*, because always in a Forced State; the Lower Parts of the *Air* being constantly press'd upon, and by the Weight of Incumbent *Air*, kept from expanding it self; but if the further it recedes from a forc'd State, the nearer it approaches to a Natural One, then the Force of the Fire must by Rarifying it, contribute to the Destroying of it's *Preternatural* State; and by the same Reason the *Air* contained in our *Pneumatical* Receiver, when Part of it is drawn out, must approach to a Natural State, the Remaining Part having further Liberty to expand it self.

To conclude this Chapter: From what hath been said, it appears, That that is truly the Natural State of a Body, in which it is preserv'd by a Natural Concourse of External Agents: And likewise from what hath been said, we may infer, That it is a common Error, *That nothing Violent is Durable*; since it is evident, that the *Atmosphere* we live in, is always in a Forc'd or Compress'd State.

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CHAP.

CHAP. XIII.

The Description of the Pneumatick Engin, and it's Use. Physico-Mechanical Experiments touching the Air, in a Letter to the Right Honourable Charles, Lord Viscount of Dangarvan.

My Dear Lord,

PERceiving that several of the *Virtuosi* at Paris, intent in Examining, how far the Air was concern'd in hindering the descent of Quick-silver, in the *Torrecellian* Experiment, concerning a *Vacuum*; I thought it seasonable to promote that Experiment; and to acquaint Your Lordship with my Attempts on that Subject, which may afford some Hints at least towards the Advancement of that Philosophy.

A Subject which I the rather make Choice of, because, the Air being of so general use in Respiration, and, by it's almost Perpetual Contiguity, as well to our own Bodies, as those we are here concern'd with, having Considerable Effects, in Producing those Various Diseases incident to Crazy Bodies, upon Changes of Weather, a Discovery of it's Nature may be of Moment; and likewise, because it may shew us how far it concurs in Exhibiting several other *Phænomena*.

But before I present Your Lordship with the Experiments, it will not be improper to give
Your

Your Lordship an Account of the *Engine* concern'd in the making of them.

It consists then of two Principal Parts; a Glass Vessel, and a Pump to suck out the *Air* contain'd in it. The First of which is a Glass, furnish'd with a Hole at the Top, to which a Cover is adapted, and also a Stop-Cock, fitted to the Extremity of it's Neck below; the Cavity of it being large enough to contain about 60 *lib.* of Water, allowing *℥xvi.* to each Pound.

The Diameter (B C) of the Top of the Vessel (A) is about four Inches, which is encompassed with a Lip, almost an Inch in Height; the Use of which is for the Cover to rest on; which is describ'd in the second Figure, where (D E) denotes a brazen Ring, which is to cover and to be closely cemented on the Lip (B C) of the first Figure. To the Internal Orifice of this Ring is adapted a Glass Stopple, so exactly, as to prevent any considerable Access of external Air: In the midst of this Cover there is a Hole (H I) about half an Inch Diameter incircld with a Ring or Socket, to which is adapted a brazen Stopple (K) so exquisitely, that it may be turn'd round without admitting in the least Air. Through the lower end of it there is a little Hole (8) made for the Passage of a String (8, 9, 10) which is likewise to pass through a small brazen Ring (L) fix'd to the bottom of the Stopple (F G) the use of which String is to move what is contain'd in the exhausted Vessel, when stop'd.

That the Stop-cock (N) in the first Figure, might more exactly exclude the Air, a thin Plate of Tin (M, T, V, W) was solder'd on the

*A Description
tion of the
Pneumati-
cal Engin.*

the Shank of the Cock (X) of a Length proportionable to the Neck of the Receiver, which was cemented, with a Cement made of Pitch, Rosin and Wood-ashes, pour'd hot into the Cavity of the Plate; and to prevent the Cement from running into the Orifice (Z) of the Shank (X) it was stopp'd with a Cork, to which was fix'd a String, that it might be drawn out of the upper Orifice of the Receiver, and then the Neck of the Glass Receiver being press'd moderately hot into the Cement, it fill'd the Interstices betwixt the tin Plate and the Receiver, and also, betwixt the Receiver and the Shank of the Cock.

The lower Part to be describ'd is made up of an Air-pump, supported by a Frame of Wood with three Legs (111) so contriv'd, that, for the freer Motion of the Hand, on one side it may stand perpendicular; a-cross the midst of the Frame, a Piece of Board is nail'd (222) to which the Pump is fix'd.

The Pump is made up of four Parts, *viz.* An exact and strong Cylinder, endued with a Cavity about three Inches cross; to which a Sucker (4455) is adapted, made up of two Parts; one of which (44) being not so large in Diameter, as the Cavity of the Cylinder, a thick Piece of tann'd Leather is nailed on it, by the Addition of which, it closes so exactly to the Cylinder, that the Air cannot insinuate; The other Part being a thick Plate of Iron (55) is firmly joyn'd to the middle of the former Part; it is a little longer than the Cylinder; one Edge of it being smooth, and the other indented,

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to the Interstices of which the Teeth of a small Jaton Nut (*a, b*) are to be adapted, which is fix'd by two Staples (22) to the under-side of the Board nail'd transverse (222;) on which the Cylinder resting, it is turn'd by the Manubrium (7.) The last Part of the Pump is the Valve (*R*) being a Hole at the Top of the Cylinder, which is taper towards the Cavity: To this is fitted a brass Peg, to be put in or taken out, as Occasion requires.

The Engine being thus delineated, the Stop-Cock must be well oyl'd with Sallad Oyl, to stop the Intervals of the Internal Surfaces of its Parts, and also, that it may with less difficulty turn the Key (*S*) at Pleasure; for the like Reasons the Sucker as well as the Valve is to be oyl'd also. And here it is as much strange as to be admir'd, That when Oyl or Water separate, have fail'd in effecting our Design, a Mixture of both hath prov'd effectual. Lastly, That the Ingress of Air betwixt the brazen Cover and the Ring, may be likewise prevented; it will be convenient to plaister the Edges with the former Cement, laid on with a hot Iron, that it may the better fill the little Cavities.

Things being thus ordered, That no Air may remain in the Cylinder, the Handle is to be turn'd till the Sucker rises to the Top of it; and then, the Valve being shut, it is to be drawn down to the bottom; by which Means, the Air being driven out of the Cylinder, and a Succession from without being prevented, the Cavity of the Cylinder must be emptied of Air, so that the Turn-cock beng turn'd so as to afford a Passage betwixt the Receiver and Cylinder,
Part

the Shank of the Cock (X) of a Length proportionable to the Neck of the Receiver, which was cemented, with a Cement made of Pitch, Rosin and Wood-ashes, pour'd hot into the Cavity of the Plate; and to prevent the Cement from running into the Orifice (Z) of the Shank (X) it was stopp'd with a Cork, to which was fix'd a String, that it might be drawn out of the upper Orifice of the Receiver, and then the Neck of the Glass Receiver being press'd moderately hot into the Cement, it fill'd the Interstices betwixt the tin Plate and the Receiver, and also, betwixt the Receiver and the Shank of the Cock.

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to the Interstices of which the Teeth of a small Jaton Nut (*a, b*) are to be adapted, which is fix'd by two Staples (22) to the under-side of the Board nail'd transverse (222;) on which the Cylinder resting, it is turn'd by the Manubrium (7.) The last Part of the Pump is the Valve (*R*) being a Hole at the Top of the Cylinder, which is taper towards the Cavity: To this is fitted a brass Peg, to be put in or taken out, as Occasion requires.

The Engine being thus delineated, the Stop-Cock must be well oyl'd with Sallad Oyl, to stop the Intervals of the Internal Surfaces of its Parts, and also, that it may with less difficulty turn the Key (*S*) at Pleasure; for the like Reasons the Sucker as well as the Valve is to be oyl'd also. And here it is as much strange as to be admir'd, That when Oyl or Water separate, have fail'd in effecting our Design, a Mixture of both hath prov'd effectual. Lastly, That the Ingress of Air betwixt the brazen Cover and the Ring, may be likewise prevented; it will be convenient to plaister the Edges with the former Cement, laid on with a hot Iron, that it may the better fill the little Cavities.

Things being thus ordered, That no Air may remain in the Cylinder, the Handle is to be turn'd till the Sucker rises to the Top of it; and then, the Valve being shut, it is to be drawn down to the bottom; by which Means, the Air being driven out of the Cylinder, and a Succession from without being prevented, the Cavity of the Cylinder must be emptied of Air, so that the Turn-cock beng turn'd so as to afford a Passage betwixt the Receiver and Cylinder,

Part

*The Method
of Man-
aging the
Pump.*

Part of the Air before lodg'd in the Receiver will be drawn down into the Cylinder, which, by turning back the Key, being prevented from flying back into the Receiver, may, by opening the Valve, and winding up the Sucker, be forc'd into the open Air; and so, by reiterated Exsuctions of the Air out of the Receiver, and Expulsions of it again out of the Cylinder, it may be exhausted as the Nature of the Experiment requires.

Having thus given your Lordship a Description of the Engine, and Cautions for the Prevention of the Ingress of Air, necessary in some more curious Experiment; I shall in short acquaint your Lordship, That the Experiments I proceed to entertain your Lordship with, are such, as require not such Exactness in the fore-mentioned Cautions, provided the Pump be well plied and the Crannies not considerable.

EXPERIMENT I.

The Manner of Pumping out the Air. A Digression concerning the Spring and Elasticity of the Air, in Order to a more, clear Apprehension of subsequent Experiments.

FROM what hath been deliver'd it appears, that, the Sucker being wound up, and, upon stopping the Valve and turning the Key, drawn down again, the Air will be equally expanded both in the Receiver and Sucker; and upon returning the Key, and opening the Valve,

near

near a Cylinder full of Air will be expell'd; but the Receiver, by reiterated Excursions, being more and more exhausted, less proportionably is forc'd out; so that at the last, before you need to open the Valve, the Sucker will rise almost to the Top of the Cylinder; and if, when it is so exhausted, you let go the Pump, and the Valve be stop'd, the Sucker, meerly by the Force of external Air, overpowering that more rarify'd Air within, will be forc'd up to the Top of the Cylinder; where we may observe, That as the Sucker is press'd higher by external Air, so it is an Argument of the Receiver's being more or less exhausted; the Air in the Sucker being accordingly more or less able to resist the external, as it varies in Quantity: We may observe also, That whilst the Receiver retains any considerable Quantity of Air, there is a brisk Noise upon turning the Key.

But to render these Experiments more intelligible, I shall take Notice to your Lordship of a Notion, which may explicate them; which is, That the Air consists of certain springy Particles, which, being bent and press'd together by incumbent Bodies, always endeavour to remove that Pressure, and to dilate themselves; which Notion may be confirmed, by considering, that the Air consisting of Parts incumbent on one another, the uppermost, by their weight, must needs compress the lower; which compressed Parts must consequently have a Power of self-Dilation: So when a Fleece of Wool compressed, upon the Removal of that Pressure again expands it self, the Springiness of the Air may likewise

A Springiness in the Air.

wife be explicated by supposing with the Ingenious *Des Cartes*, that the Air is a *Congeries* of flexible Particles, of various sizes and very irregular Figures, raised by the Heat of the Sun, and swimming in that Matter, which encompasses the Earth; which being, by that *Aether* that floats about them, kept separate and in a violent Agitation, acquire that Springiness which they would lose in some measure by being compressed.

By both these ways the Springiness of the Air may be explained; yet by which with most Reason I shall not now dispute, being not so much concerned about the adequate Cause of that Springiness, as to manifest, that it hath a Springiness, in order to shew the Effects of it; for I am not satisfied, whether either so far explains it's Nature, as to make it intelligible.

But in opposition to this Notion it may be alleged, that tho it were granted, that the Air is made up of springy Particles; yet, it would only account for the Expansion, and the Dilatation of the Springs of the Air, when apparently compressed in Wind Guns and other Pneumatical Engines; whereas from these Experiments it does not appear, that there was any Compression before the Air was included in those Guns. To remove this Difficulty, there are several Experiments which prove, that our Atmosphere is not light, but heavy, in respect of some Bodies, one of which I shall mention here, which is this, that a Lamb's Bladder dried, whose Cavity contain'd two thirds of a Pint, being press'd together, and counterpoised in a very nice Balance, and being prick'd, upon the avolition of the Air

Air contain'd in it, lost a Grain and an eighth Part of what it weigh'd before; from whence, if we may conceive, that it hath weight, it follows, that a Column of Air of many Miles high leaning on those below, is enough to compress and bend their Springs; as when Wool is heaped to a considerable height, that which lyes under is compressed by that which lyes upon it; and if upon a Parcel of Air, so large a Quantity lyes, no wonder, that upon the Removal of that Pressure, it powerfully expands.

As for the Objection, that Water varies not in it's Weight in the lower from the upper Part, it may be answered, that the difference betwixt Air and Water is very considerable; the last not being capable of Compression; whereas Air is. To which may be added the Experiment tryed by Monsieur *Pascal* (the Son) at the foot, the middle and top of that high Mountain (in *Auvergne*) called *Le Puy de Domme*, where the *Mercury* subsided above three Inches more at the Top than the bottom; the Reason of which is, that the Air less vigorously pressed against the Quicksilver at the Top, and so was less capable of bearing it up.

Why Mercury is suspended higher at the bottom than the top of a Hill.

And if it be objected against what hath been proposed, that if it were so compressed, it would not be so ready to yield to the slight Force of Flies, and even Feathers, it may be answered, that as a Piece of Wool squeezed together, makes a manifest Resistance to the Pressure of the Hand; so the Air does to those Bodies, tho it's Resistance is not strong enough to overpower their Motion, the Parts of it being in a continual Disposition to yield to solid Bodies, upon the Account of it's Fluidity,

Fluidity, and the perpetual Motion of it's Parts, occasioned by their continual Endeavours to expand and unfold themselves.

EXPERIMENT II.

Of the Pressure of the Air against the Sides of the Bodies it encompasses. The Pressure of the Air included within an Ambient Body explain'd.

The Air presses upon the sides of Bodies it encompasses.

IF, when the *Air* is almost drawn out of the Receiver, one endeavours to lift up the Brass Key which is plac'd in the middle of the Brass Cover; it will be as difficult to raise it, as if a considerable Weight were ty'd to it; for the Spring of the *Air* included in the Receiver being weaken'd, and not able to bear up strong enough against the bottom of the Stopple, as powerfully as before; whoever lifts up the Stopple, must likewise bear up the whole Pillar of External *Air*, which presses upon the top of the Stopple: But if the *Air* be gradually permitted to get into the Receiver, the Internal *Air* being more compress'd, and its Spring encreas'd, it bears up against the Stopple more powerfully, and the Pressure of the Internal and External *Air* being brought nearer to an *Equilibrium*, the Stopple may proportionably be lifted up with less difficulty; till at length, the whole Cavity of the Receiver being fill'd with *Air*, it may easily be taken up.

But it's thought strange by some, how the Pressure of the Included, can be any ways proportionable to the Pressure of the External *Air*; since it is so encompass'd by the sides of the

the Receiver, that those Pillars of Air, which would press upon it, if open to the Air, are only incumbent on the External *Superficies* of the Receiver; but to unfold this Difficulty, we may consider, That as a piece of Wood squeezed in ones Hand, and so enclos'd in a Box, is kept from expanding equally by the sides of the Box, as if it remain'd in ones Hand; so the Air compress'd by the Incumbent *Atmosphere*, and conveigh'd in that compress'd State, into the Receiver, is equally kept from expanding it self by the sides of the Receiver, as if it were still squeez'd together by the weight of the *Atmosphere*: And if it should further be objected, that if the Air included in the Receiver were so confin'd by the sides of it, it's continual Endeavour to expand would break the Glass: It may easily be answer'd, that the expansive Force of the Internal Air, is counterpois'd by the Compressure of the External, and consequently there being an equal Pressure on both sides, it is preserv'd entire; for a like Reason those slender Bubbles, which Boys usually blow up with Soap and Water, continue whole for a good while, the Internal and External Air, being compress'd to a just *Equilibrium*.

EXPERIMENT II.

Concerning the Force requisite to draw down the Sucker: The Opinion of a Modern Naturalist examin'd.

Though the Sucker may be easily drawn down, by the help of the *Manubrium*, yet without that it will require a Force capable of

What Weight is requisite to draw down the Sucker.

of raising so much of the *Atmosphere* as presses upon it: The Reason of which is evident, from *Mercury* suspended in a Tube; for tho' the Weight of the *Atmosphere* is able to ballance and keep it up to twenty five Digits; yet if the suspended *Mercury* exceeds that height, it presently over-powers the Pressure of the incumbent *Atmosphere*, and subsides to its just height. And as from hence we may learn, why it is so difficult to draw down the Sucker; so it likewise teaches us, for what Reasons the Sucker, when so violently forced down, upon a Relaxation of that Force rises up again; for the Spring of the Air included being weak, it must consequently be buoy'd up by the Pressure of the External, till that which is contain'd in the Receiver be equally compress'd, so as to be able to resist the Pressure of the *Atmosphere*. There is one Thing more remarkable in this Experiment, which is, that if the Valve be stopped close, when the Sucker is rais'd to the Top of the Cylinder, it finds an equal Resistance by the Pressure of the *Atmosphere* when first drawn, as when nearer the Bottom of the Cylinder; from whence we may gather, that what an Eminent Modern Naturalist delivers concerning the Reason of the violent Ingress of exhausted Air, viz. *That it is increas'd by the Addition of that Force, which it receives from the Air sucked out*, is a mistake; for were it so, it would be more difficult to draw down the Sucker, when it is further from the Receiver, a greater quantity of Air being exhausted. But from what hath been premis'd in the first Experiment, it is evident, that the weaken'd Pressure of the Internal Air,

is

is sufficient to account for the more violent Ingress of the External.

EXPERIMENT IV.

Concerning the Swelling of a Bladder, The Opinion of a Learned Author Examined.

HAVING convey'd into the Receiver a *Lamb's Bladder*, well dry'd and limber, and half full of Air, the Cover being luted on, and the Pump set on work; we observ'd, that as the Air in the Receiver was gradually exhausted, that in the *Bladder* was accordingly expanded, till the Receiver being near fully exhausted, the *Bladder* seem'd very much distended, with the included Air. And to confirm our Guess, that the Expansion of the Air in the *Bladder*, proceeded partly from the weaken'd Pressure of the ambient Air, we gradually left in the external Air, and found, that the *Bladder* by degrees subsided till it became as empty as before: But one thing Remarkable in this Experiment was, that the more the Receiver was exhausted, the more sensibly the *Bladder* was distended.

And lest in this Experiment it should be doubted, whether the Distention of the *Bladder* did not rather proceed from the *Fibres* of the *Bladder*, returning of their own accord, to their natural Extension upon the removal of the external Air, we put in two empty *Bladders* along with the former, and found them very little extended upon the Exsuction of the Air. And the like *Phænomena* were afforded, by repeating the Experiment with a *Bladder*, which

was half empty, and half fill'd with Air, the empty Part being parted from that which contain'd the Air, by a Ligature.

EXPERIMENT V.

Concerning a Bladder which burst in the Receiver, and another by Heat.

*The Force of
the Airs Ex-
pansion.*

HAVING put a *Bladder* moderately Blown into the Receiver, before the whole Air was drawn out, the Air presently expanded and broke the *Bladder* with a considerable Crack; and tho this Experiment frequently succeeds, yet if the *Bladder* be one that is too dry, it is hard to tie it so fast, but that some of the included Air will get out, and so frustrate the Tryal. But to be fully inform'd whether the Air is out or not, we may be satisfi'd, by admitting Air afresh into the Receiver, which will, if the mention'd Accident happens, compress the *Bladder* more than when it was first put in. But it is not only possible, that the Air should expand it self so powerfully in an exhausted Receiver; but if a *Bladder* well blown, be brought near a good fire, the included Air will burst the *Bladder* with a considerable Noise.

EXPERIMENT VI.

*The Airs
Expansion
measur'd.*

TO try how much the Air was capable of being expanded, we fix'd the Neck of a wet Lamb's *Bladder* to the Neck of a Viol; which being convey'd into the Pneumatical Receiver, upon the Exsuction of the Air, we observ'd, that the

the Air which was contain'd in the Cavity of the Viol was so far expanded, that tho' the Viol was able to contain above five Drachms of Water, it filled and distended the empty Bladder, which was large enough to hold five Ounces and half a Drachm. In which Experiment, the expanded Air possessed nine times as much space as it did before Expansion.

But to measure the Air's Expansion more nicely, we fix'd a Glass Bubble to one end of a Cylindrical Pipe, hermetically sealed; the Diameter of whose Bore was about a quarter of an Inch; and having pasted a Piece of Parchment upon the outside of the Tube, which was divided into twenty six equal Parts, and mark'd with black Lines, we fill'd the Cylinder almost full of Water, so that, after a few Tryals, by inverting the Cylinder, and stopping the open End with one's Finger, we could perceive, that as much Air might be permitted to rise up to the Bubble, as was equal in Extension to the Breadth of one of those twenty six Divisions; When this was done we fitted the open end of the Cylinder to a Glass Viol, which was fill'd with Water to the Height of half an Inch; all which being put together into a Pneumatical Receiver, after a few Exsuctions, the included Air was so much expanded, as to extend it self to the Surface of the Water; in which Experiment the expanded Air took up thirty one times as much Space as before.

And this Experiment being repeated in a Cylinder, which afforded a larger space for the Air's Expansion, it took up above sixty times the space it did before. And repeating the like Ex-

periment with a Glass Pipe thirty Inches long (part of it having a Hole in the Cover to stand out through) by weighing the Water in a nice Pair of Scales together with the Pipe, first with the Bubble of Air included, and after when the Tube was wholly filled with Water, we found, That the Air which possessed but the Space of one Grain of Water had been expanded, in the exhausted Receiver so much by its own *elasticity*, as to take up 152 times its Space before Extension.

And since *Marcennus* affirms, That the Air may be so expanded by Heat, as to take up seventy times its Space, I conveyed a Cylinder of the former Magnitude into the Receiver, and found, That upon the Exsuction of the Air in the Receiver, that in the Cylinder descended down almost to the bottom of it, the lower Surface of it being very convex, and seeming several times to knock upon, and rebound from the bottom of the Viol; which was an Argument of the expansive Force of the Air; since the Water it depressed, upon the drawing out of the Air, was much below the Surface of the Water contain'd in the Viol.

EXPERIMENT VII.

What Figure best resists the Pressure of the AIR.

HAVING got a thin Glass Bubble, which was large enough to hold about five Ounces of Water, to which was fix'd a slender Neck, about the Bigness of a Swan's Quill, we moderately exhausted the Air out of the Receiver, and then taking it out of the Pump, we joyn'd

joyn'd the Neck of the Bubble to the lower Orifice of the Receiver, stopping the Crannies with melted Plaster to prevent the Ingress of the Air; and tho' the Glas was as thin as Paper, yet upon turning the Key of the Stop-Cock, and giving the Air included in the Bubble Liberty to expand, the Bubble sustained the Pressure of the whole *Atmosphere*, without being broke.

EXPERIMENT VIII.

WE took a Glas Alembick, which was large enough to hold about Three Pints, represented by the *Seventh Figure*; The *Rostrum* (E) being hermetically closed: In the Top of the *Rostrum* was a Hole, into which, one of the shanks of a Stop-Cock of an ordinary size was cemented, the other being fixed with Cement in the upper Part of the Pump; which being done, and the upper Orifice of the Alembick being covered close with a Plate of Lead exactly adapted to it, upon drawing the Air out of the Receiver the Glas presently cracked; which Crack is represented by the Line (a, b) and this Flaw extended it self further accordingly as the Air was more exhausted, yet this Glas Vessel was near twenty times thicker than the Bubble.

The former Experiment illustrated.

And that the Figure of the former Glas enabled it so much better to sustain the *Atmosphere*, was further confirmed by suspending one of the Bubbles hermetically sealed in the Receiver, which so strongly resisted the Expansion of the Air contained in it, as to continue whole, when the Receiver was exhausted.

EXPERIMENT IX.

A Confirmation of the former Experiment: An Experiment to shew that these Phænomena exhibited in Vacuo Boyliano proceed not from a fuga Vacui, &c.

A Confirmation of the former Experiment, &c.

HAVING put the end of a slender Glass Pipe into a Viol, which was large enough to contain four Ounces of Water, and fixed it to the Neck of the Viol with a Cement of Rollin and Pitch, so that the end of the Pipe almost touched the bottom of the Viol, as in *Fig. 6*, this Viol was conveyed into a small Receiver, as much Water being put into it, as wrought a little above the bottom of the Cylinder; the upper End of the Pipe being most of it without the Vessel, a Hole having been purposely made for it in the Top of the Receiver: The Event of which Tryal was, that upon drawing the Air out of the Pump, the Weight of the *Atmosphere* internally pressing into the Pipe, and the Spring of the Air within the Receiver, not equally pressing against the sides of the Bottle, which were exposed to it, a Piece of the Bottle burst out of the side of it, with such a Force as to crack the Receiver in several Places; and having reiterated the Experiment with a round Glass Bubble, the Leaden Cover of the Receiver was not only depressed, by the Weight of the *Atmosphere*, so as to thrust out one side of the Receiver, but the Glass Bubble was cracked into Pieces with such violence, as to tear a Bladder, which it was encompassed with to keep it from breaking the Receiver, in several Places.

Before

Before I proceed to the next Experiment, it may be requisite to advertise, That though the larger Receivers are apt, upon some Tryals, to crack; yet, they are not rendered altogether useless, since when the Air begins to be exhausted, the ambient *Atmosphere* compresses the Lips of the Glass closer together. But if the Crack be considerable, it may be cemented with a Plaster made of Quick-lime and Scrapings of Cheese ground together very finely in a Mortar, and made into a Paste with a little Water, which being spread upon a Cloath about three Inches broad, must be apply'd to the Crack.

EXPERIMENT X.

HAVING suspended a Tallow Candle in ^{Of the} our Receiver, we found, That upon an ^{Flame of a} Exsuction of the Air, it was presently extin- ^{Candle in} guish'd; but another being suspended there ^{a Receiver.} without pumping the Air out, it burn'd a little longer, the Flame of both before they went out gradually contracting and ascending almost to the Top of the Wieck with a blue Flame. In which Experiments it was observable, that when the Air was drawn out, the Wieck was presently extinguish'd, emitting very faint Effluvioms, which rose a little Height; and dispers'd themselves in the Receiver very faintly; whereas when the Air remain'd in the Vessel, the Smoak ascended in a Cylindrical Stream, very briskly and recoyl'd from the Cover. To try what difference there would be in the *Phænomena*

moneta exhibited by a Candle made of Virgin's Wax, and the former, I suspended several small ones, stuck together, and found, that they would be immediately extinguish'd before the Cover could be cemented on; but having let down one of them alone, we observ'd, that upon the Evacuation of the Air, it continu'd to burn about a Minute; but if the Air was not pump'd out, the Flame continu'd more vivid and lasting: And, as in the Former Experiment, the Flame gradually rose to the Top of the Wick; so in the Latter, it was depress'd nearer the Bottom, before it was extinguish'd.

EXPERIMENT XI.

Concerning the Burning of Coals, and the Continuance of the Heat of a piece of Iron in Vacuo Boyliano.

HAVING suspended a Screw made of Wire in the Receiver, such as *Fig. 10.* represents, it being first fill'd to the height of five Inches, with live Wood-coals; upon the first Exsuction made by the Pump, they grew dim, and the Pump being ply'd for three Minutes, they were quite depriv'd of their red Colour, and seem'd extinct; but when they were taken out of the Receiver, they were re-kindled again; and being let down into the Receiver afresh, without Pumping out the Air, they continu'd red for a Minute longer than before; but a like quantity of Live-coals, continued to burn half an Hour, in the open Air.

But

But a piece of Red-hot *Iron*, being suspended in the same Wire, upon an Exsuction of the Air, it seem'd not to be sensibly alter'd; but continu'd red for 4 Minutes; neither was it alter'd by re-admitting the Air into the Receiver, tho' Fumes, which were rais'd from some Wax, which stuck to the Wire, were much more expanded, when the Air was pump'd out, than upon it's re-ingress. But one thing observable, was, that whether the Air was suck'd out, or not, the sides of the Receiver were considerably heated by the *Effluvia* trasmitted from the *Iron*.

E X P E R I M E N T XII.

HAVING suspended a lighted Match in the Receiver, it presently fill'd the whole Capacity with Smoak; which, together with Air, being pump'd out, we could discern the Match to burn still more languid, till at the last it seem'd to be totally extinguish'd; yet some time after, upon a fresh ingress of Air, it renew'd it's Fire, being blown up a-fresh by the Access of that Aery Body.

*Concerning
the Burning
of a Match.*

E X P E R I M E N T XIII

HAVING suspended a lighted piece of Match, together with a Bladder, to try whether the Smoak would hinder the Distention of the Bladder, as also whether the Light of the Match would be put out by it's own Smoak; I observ'd, that it afforded the same *Phænomena* mention'd in the foregoing *Experiments*, except that after Successive Re-admissions of the Air, it being

*The Reason
of the afore-
mentioned
Effect.*

ing excluded for some time, the Fire was totally extinguish'd.

Besides which, the following *Phænomena* were to be observ'd: First, That upon the turning of the Stop-Cock, the Cavity seem'd immediately darken'd, as if it proceeded from a Change of the Position of the Parts of the Smoak. Secondly, That a kind of *Halo*, consisting of some Exhalations hover'd about the Flame. And Lastly, It was observ'd, that the Fumes did not in the least obstruct the Distension of the Bladder.

Having try'd the Former *Experiment* with a lighted Match, in a small Receiver, I found, that the Fire was quite extinguish'd with it's own Smoak, before the Cover could be cemented on, except the overplus of Smoak was successively pump'd out, and a Supply of Fresh Air was let in at the Stop-Cock; which Method would contribute to the Preserving of it,

EXPERIMENT XIV.

Of the Striking of Fire, and Explosion of Gun-powder in Vacuo Boyllano.

Gun-pow-
der explo-
ded in Va-
cuo Boylla-
no, &c.

HAying fasten'd a Pistol to a Prop, which was plac'd in a Perpendicular Situation in the Receiver, and having ty'd a String to the Tricker, the other End of which was fix'd to the Key above-mention'd, in the middle of the Cover, we turn'd the Key round, to shorten the String; by which means the Tricker being check'd, and the Flint as it is usual, falling upon the Steel, it struck Fire, tho' the Receiver was exhausted, as a Pistol usually does; tho' by the strongest

strongest Collision we could contrive, we could not, in our Engin, strike Fire with two pieces of Steel, striking one upon another.

But we observ'd, That having endeavour'd several times, without Success, to fire Gunpowder, we, but once or twice, met with the desir'd Effect: Where we observ'd, That the Flash was more expanded, than if it had been exploded in the open Air; and that when the Flash was extinguish'd, the Receiver was full of Smoak, the Parts of which mov'd up and down very briskly, but much swifter, when Air was permitted to return into the Cavity of the Receiver.

EXPERIMENT XV.

The Unusefulness of Kindling Bodies inclos'd in Vacuo Boyliano, with a Burning-Glass.

HAVING conveig'd some Black and Dark Combustible Matter, into a small Receiver, and plac'd it in the Sun-shine; a Good Burning-Glass threw the Rays of the Sun so powerfully upon it, as to make it smoak, and fill the Receiver; but the Air getting into the Cavity of it, we could not prosecute the *Experiment*. And having repeated the Tryal in our Large Receiver, we found the Glass so thick, that it broke the Rays of Light, and scatter'd them so much, that when they fell upon the Combustible Matter, they were altogether incapable of working any considerable Effect upon it.

EXPE-

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EXPE-

EXPERIMENT XVI.

*The Opera-
tion of a
Load-stone.*

HAVING plac'd a piece of Wood in our Receiver, with a piece of Iron, in a Perpendicular Line, upon it; and fix'd a well-poiz'd Needle upon that, we pump'd out the Air, and then apply'd a Needle to the outside of the Receiver; and observ'd, That the Load-stone drew or repell'd the Needle, as a Load-stone usually in the open Air; and the Needle, upon a Removal of the Load-stone, after some tremulous Vibrations, pointed North and South again.

EXPERIMENT XVII.

The Gravity and Rarefaction of the Air examin'd, by the Torrecellian Experiments; together with Considerations concerning a Vacuum, &c.

The Gravity of the Air, &c.

CONSIDERING that it would be a very probable Method, to inform us, how far the Pressure of the Atmosphere, contributes to the buoying up of Mercury, in a Cylinder, so many Digits above the Surface of the Mercury it leans on, to try, whether in our Engine, as the Air was more or less exhausted, the Mercury in the Tub would accordingly subside; we fill'd a Glass-Cylinder Hermetically seal'd with Mercury, whose Bore was about a quarter of an Inch Diameter, and 3 Foot long; which being inverted in an oblong Box, and carefully let down into the Receiver; and the Cover luted on, the Tube came through the Hole in the midst of the Cover, the Crannies being fill'd with melted Diachylon; where it was obser-

observ'd, That the *Mercury* remain'd elevated to the same height, as if the Foot of the Tube had been press'd upon, by the *Atmosphere*, the Air included in the Receiver being in a compressed State, and acting by Virtue of it's Spring.

The Cylinder of *Mercury* being thus plac'd in the Receiver, we caus'd a Cylinder of Air to be pump'd out, and after that, another, observing the *Mercury* after each, gradually to subside; till at the last, it subsided a considerable way in the Pipe, down into the Body of the Receiver: and to put it beyond dispute, that the Subsiding of the *Mercury*, depended upon the weaken'd Spring of the included Air, and the *Equilibrium* betwixt the Pressure of that, and the Gravity of the *Mercury*; we turn'd the Key, and permitted Air gradually to re-enter; and observ'd, That the *Mercury* accordingly rose in the Pipe, almost to the height which it was first suspended at; and the Reason why it was not rais'd quite so high, was, because several Bubbles of Air, which were before mix'd with the *Mercury*, rising above it, deprefs'd, and kept it from ascending, by taking up more room in the Top of the Cylinder.

In trying of which *Experiment*, having once made use of *Diachylon* Plaster, to stop up the Top of the Tube, we found, that tho' the *Mercury* subsided considerably upon the Operation of the Pump; yet the Air so powerfully insinuated it self through the *Diachylon* Plaster, that it sunk in the Pipe insensibly of it self.

Another thing observable in this *Experiment*, was, that if, when the Air was exhausted, it were again permitted to run in too fast, it would

go near to break the Cylinder, by forcing the *Mercury* up too quick.

Besides we observ'd, as we have before intimated, That tho' upon the First Exsuctions, the *Mercury* subided above an Inch; yet when it was low in the Receiver, it would not subside over the Breadth of a Barley-corn; besides, by reason of the Parts of the Air, tending to a Restitution of their Springs, it check'd and caus'd the *Quick-silver* after it's descent, to fly back again a little after each Exsuction.

Another thing remarkable in this *Experiment*, is, That having try'd it in one of our small Receivers, we found, that at one Exsuction it fell 18 Inches and a half, and at another time 19 and a half; from whence we may infer, that it might be of no small use to consider, the various *Phænomena* afforded by the different Magnitude of the Receivers, in which these *Experiments* are made; and also the various Bores of the Cylinders, which contain the *Mercury*; for thence one might probably guess at the Quantity of Air extracted out of the Receiver, by the Subsiding of the *Mercury* in the Tube.

To the foregoing Observations, we shall add, That having once try'd the *Experiment*, in a Tube about two foot long, I found, that upon the first Exsuction, the *Mercury* fell above a Span, and afterwards subided by degrees, till the Air was re-admitted, and then it was rais'd near to the top of the Tube again.

Lastly, It hath been observ'd, That when, by the help of the Pump, more Air hath been squeez'd into the Receiver, than what was forc'd in by the Weight of the *Atmosphere*, the *Mercury* would

would rise above 27 Digits in the Tube, and would be sustented at that height, till the Air was again let out.

Having said thus much of the *Terræstris Experiment*, and the several *Phænomena* observable in it, perhaps it may be expected, that I should say something, concerning that Controversy, Whether or no there be a *Vacuum* in the Receiver, when the Air is pump'd out: But being unwilling to take it upon me to determine so nice a Controversy; I shall only intimate, that were the Cavity of the Receiver void of Matter, it would be a difficult thing to conceive, how we should have visible *Heads* of things contain'd in it; since they must either be convey'd thence by the reflected Rays of Light, or they must proceed from some *Scintillæ* Emanations from the Bodies themselves. And from the foregoing Sixteenth *Experiment*, it appears, That the *Effluvia* of a *Loud-flower* do permeate the Cavity of the Receiver, which makes it probable, that the Magnetical Steams of the Earth do so too.

But on the other hand, it may be alledged, That since the *Effluvia* of a *Loud-flower* may be admitted into the Receiver, when it seems full of Air, it may be arg'd, that the little Emanations of that Substance are not diffus'd through the Vacuities of the Air, and consequently when the Air is exhausted, the Space or void the Air possess'd before, may be left void of Matter, for when the Thirteenth *Experiment* appears, the Matter, which, if closely join'd together, takes up but a small Space, may be diffus'd through out the Receiver, a very small portion of the Mass being able to fill the whole, as may be seen

go near to break the Cylinder, by forcing the *Mercury* up too quick.

Besides we observ'd, as we have before intimated, That tho' upon the First Exsuctions, the *Mercury* subided above an Inch; yet when it was low in the Receiver, it would not subside over the Breadth of a Barley-corn; besides, by reason of the Parts of the Air, tending to a Restitution of their Springs, it check'd and caus'd the *Quick-silver* after it's descent, to fly back again a little after each Exsuction.

Another thing remarkable in this *Experiment*, is, That having try'd it in one of our small Receivers, we found, that at one Exsuction it fell 18 Inches and a half, and at another time 19 and a half; from whence we may infer, that it might be of no small use to consider, the various *Phænomena* afforded by the different Magnitude of the Receivers, in which these *Experiments* are made; and also the various Bores of the Cylinders, which contain the *Mercury*; for thence one might probably guess at the Quantity of Air extracted out of the Receiver, by the Subsiding of the *Mercury* in the Tube.

To the foregoing Observations, we shall add, That having once try'd the *Experiment*, in a Tube about two foot long, I found, that upon the first Exsuction, the *Mercury* fell above a Span, and afterwards subided by degrees, till the Air was re-admitted, and then it was rais'd near to the top of the Tube again.

Lastly, It hath been observ'd, That when, by the help of the Pump, more Air hath been squeez'd into the Receiver, than what was forc'd in by the Weight of the *Atmosphere*, the *Mercury* would

would rise above 27 Digits in the Tube, and would be suspended at that height, till the Air was again let out.

Having said thus much of the *Torrecellian Ex-periment*, and the several *Phænomena* observable in it, perhaps it may be expected, that I should say something, concerning that Controversy, Whether or no there be a *Vacuum* in the Receiver, when the Air is pump'd out: But being unwilling to take it upon me to determine so nice a Controversy; I shall only intimate, that were the Cavity of the Receiver void of Matter, it would be a difficult thing to conceive, how we should have visible *Idea's* of things contain'd in it; since they must either be convey'd to our Sensory by the reflected Rays of Light, or they must proceed from some sensible Emanations from the Bodies themselves. And from the foregoing Sixteenth *Experiment*, it appears, That the *Effluvia* of a *Load-stone* do permeate the Cavity of the Receiver, which makes it probable, that the Magnetical Steams of the Earth do so too.

But on the other hand, it may be alledg'd, That since the *Effluvia* of a *Load-stone* may be admitted into the Receiver, when it seems full of Air, it may be urg'd, that the subtle Emanations of that Substance are only dispers'd through the Vacuities of the Air; and consequently when that Air is exhausted, the Spaces which the Air possessed before, may be left void of Matter; for from the Thirteenth *Experiment* it appears, that Matter, which, if closely pinned up together, takes up but a small Space, may be dispers'd throughout the Receiver, a very small Portion of the Match being able to fill the whole Cavity of it

with Fumes. And as for the Arguments before alledg'd in favour of a Plenitude; they rather seem to argue, that it may be, than that it really is; and the Consequences usually drawn in Proof of such a Plenitude, are rather grounded on the *Cartesian* Notions of a Body, than on Substantial Experiments; for they thinking it a Contradiction in Adjecto so say, a Space can be void of Body, since they make Body and Extension inseparable; they therefore in favour of their own Doctrin draw Inferences from their own Positions to argue for a Plenitude.

But to leave so Nice and Doubtful a Dispute, I shall proceed to lay down the following Advertisements: First, That the Difference which sometimes happens betwixt the rising of *Mercury* here in *England*, and beyond Seas, being about two Digits, it rather proceeds from the Shortness of our *English* Inches, compar'd with those beyond Seas, than any such considerable Difference in the Weight of the *Atmosphere*. Another thing to be advertised is, That except more than ordinary Care be taken, when the End of the Cylinder is immers'd in the Vessel of *Mercury*, several Bubbles of Air will rise to the Top of the Tube, which, being condensed with Cold, will permit the *Mercury* to rise higher in the Tube; but being expanded with Heat, would sensibly depress it. And,

If it should be demanded, What Methods are to be taken to prevent the Intrusion of the Air, the following Requisites are to be observ'd: First, the lower Orifice of the Cylinder must be smooth, and so much inverted on each side, as not to exceed a quarter of an Inch in Diameter.

Se-

Secondly, the Tube must be fill'd so full, as not to admit of any Air, betwixt the Finger and the *Mercury*. Thirdly, before the Tube is quite fill'd, it will be requisite to invert the Tube, that the Air included in it, may, by ascending to the Top, and upon a Re-inversion back again, gather all those little Bubbles of Air, which are dispers'd through the *Mercury*, as it passes from one end of the Cylinder to another; and to drain the *Mercury* more exactly you may, by applying a hot *Iron*, cause those less Bubbles, which are not excluded by the former Method to break forth, which will be promoted by shaking the Vessel upon every Drop of *Mercury*, put into the Pipe. By which Method, having in a great Measure clear'd the Tube of Air, I have, in one, that was pretty short, rais'd the *Mercury* to no less than 30 Digits and an eighth.

EXPERIMENT XVIII.

The Variation of the Rise of the Mercury in the Glass-Cylinder, and the Reason of it consider'd.

HAVING fill'd a Tube about 3 foot long, with *Mercury*, and plac'd it in a wooden Frame in the Window, I observ'd, the *Mercury* was sensibly depress'd in hot Weather, by the Expansion of the Air, which swam about it, and rais'd again in Cold; the Altitude very often varying without any manifest Cause: So that in five Weeks time it had ascended and descended about two Inches; the utmost descent below the Altitude of it's first Suspension, being $\frac{1}{2}$ of an Inch; and it's utmost Descent being $\frac{1}{4}$, and it is

X 2

not

not improbable, but that the Variation of the Altitude of the *Mercury*, would have been more considerable, had the Experiment been try'd in a longer Tube, and in the open Air.

And here it may be seasonable to take notice, that could there be any sensible Variation, observ'd in the Altitude of the *Mercury* upon the Ebbing and Flowing of the Sea; it would be of no small Moment in determining whether the Pressure made upon the Air, by the Moon, were any ways concern'd in causing the Ebbing and Flowing of it, and such like *Phænomena*.

But to return to what we observ'd further: Having taken the Cylindrical Tube out of the wooden Frame, on a snowy day we observ'd, that the *Mercury* was rais'd Twenty nine Digits and three Quarters, above the *Bas*is which it lean'd on.

If it should be ask'd, from whence these Variations in the Altitude of the *Mercury* proceeded? I shall offer the following Considerations.

The Reasons why Mercury is not always equally suspended.

First. That the Air above the *Mercury*, being very weak, and not able to make any strong Resistance to the Rising *Mercury*, it may be esteem'd a Cause, why it rises no higher, because the *Atmosphere* is able to sustain no more of it; forasmuch as the *Mercury* and the *Atmosphere* are ballanc'd in an *Æquilibrium*; for the Resistance which the Air above the *Mercury* can make, is so small, that it would rise but very little higher, were there none at all in the Top of the Tube.

Secondly,

Secondly, We may consider, that the External Air is subject to many more Alterations and Changes, than the Internal contain'd in the Top of the Tube, the latter being subject to be wrought on only by Heat and Cold: But the former is subject to many and considerable Alterations, besides those observable in this Experiment, the Effect of its fainter Changes being evident by their Effects on bruis'd and feeble Bodies. And that there are considerable Changes in the Air, Considerable Changes in the Qualities of the Air. is further evident from what Kircherus, during his Stay in Malta observes concerning Mount Aetna, which he could see from that place on some days, tho' on others, which seem'd clear, the Air was so condensed, that he could not discern it; and that the like Changes of the Air have sensibly alter'd the Prospects of several Places, is too commonly known to need further Instances: And we our selves have often taken Notice of plentiful Steams and Exhalations in the Air, by the use of Telescopes, which could not otherwise be taken notice of, which after a Shower of Rain would presently disappear: And that such Steams do rise from the Earth, hath been observ'd by Miners, who are often too sensible of Damps, which except timely prevented, make the Air so thick and muddy, as to put out their very Candles. And that the Thickness of the Air may contribute to the raising of the Mercury in the Pipe, appears from what hath been before observ'd in the Torrecellian Experiment.

And since the External Air is liable to be alter'd so many ways, by the Mixture of insensible Corpufcles of Matter, its Rarity and Densi-

ty are sufficient to account for the several Variations in the Height of the suspended Mercury; since accordingly as the Air is Rarifi'd, its Pressure in Bodying up the Mercury must accordingly be varied.

EXPERIMENT XIX.

The subsiding of a small Cylinder of Water.

TO try whether a Cylinder of Water would subside in our Receiver as the Cylinder of Mercury did, we fill'd a Cylinder of four foot long with it, which being inverted, and the lower end placed in a Glass Vessel, we let it down in the Receiver and closed it up; which being done, and the Pump set on work, we found that it did not in the least subside till such a Quantity of Air was exhausted, as to leave the included Air so much weaken'd in its Spring as to be work'd upon, and over-power'd by the weight of the Water; and then, upon every Suction, it sensibly subsided, tho' not so much as the Quicksilver; for whereas the Quicksilver subsided till it fell within an Inch of the *Basin*, the expanded Air remaining in the Receiver, was able to bear up the Water a Foot high. But the Experiment being try'd in a small Receiver, the Quantity of Air included in that, coming nearer to an *Equilibrium* with the Cylinder of Water, it sensibly subsided upon the first Exsuction; and much lower upon the second, and sometimes not much less than two foot; and the Water in this as well as the former, upon a reingress of Air rose to the Top of the Cylinder, but with more Speed than the former.

E X P E R I M E N T XX.

TO evince that Water hath, besides a notable one, a languid Elater, we fill'd a ^{Concerning the Elater of Water.} Glas Bubble with a long Neck, term'd by the Chymists a Phylosophical Egg, about a Span above the Bubble, with Water; where fixing a piece of Paper, we convey'd it into the Receiver, and found, that, after part of the Air was pump'd out, the Water sensibly rose upon every Exsuction, the breadth of a Barly-Corn; and upon the ingress of the Air presently subsided to its former place. Another Instance of the Air's Expansion, I obtain'd by filling a round Pewter Vessel with Water at a small Hole, which being stop'd with Soder, and the Vessel bruis'd in several places, to compress the Water, the Vessel being perforated with a Needle, it spun out with Force enough to raise it a considerable height into the Air.

E X P E R I M E N T XXI.

HAVING fill'd a Glas Viol with Water, which ^{Concerning the same.} contained something above a Pound, I took a Glas Pipe, about as thick as a Goose Quill; and having put one End of it into the Neck of the Bottle, and clos'd it with Cement, I fill'd the Pipe half full with Water, sticking a piece of Paper at the Superficies of the Water on the outside of the Pipe, which being plac'd in the Pump, after the Air had been pump'd a while; above sixty Bubbles of Water as big as Pease rose out of the Water, one after another;

and the Water in the Bottle so far expanded, as to rise quite up to the Top of the Pipe; and being permitted to subside, several Bubbles of Air rose out of it afresh, as soon as it renew'd its Expansion as before; but upon a reingress of the Air, it presently subsided almost to the Bottom of the Pipe.

Besides which, the following *Phænomena* were observable: *First*, That those Bubbles, which ascended last, were much larger than the former, either, because their Parts were more expanded than before, or because more Bubbles of Air were united together, but whatever was the Cause of it, we observ'd, that they ascended much slower than before.

Another thing to be observ'd was, that tho' Bubbles are usually wont to rise above the Surface of the Water, encompass'd with a thin Film; yet, in this Tube, the Surface of the Water being Convex, the less protuberant Parts of the Bubble were covered with Water.

Another Observation which occur'd was, that whereas those Bubbles which rose at the Beginning of the Operation, divided the Water which they pass'd through, in their Ascent; these latter expanded Bubbles, filling up the Cavity of the Cylinder in their Passage, rais'd the Water before them; till the Air was again permitted to re-enter the Receiver, and then they wholly disappeared.

From which Observations it may Naturally be inferr'd; *First*, Bodies under Water may be press'd upon by the *Atmosphere*, as well as incumbent Water; *Secondly*, It cannot be hence inferr'd, that the Intumescence of the Water
pro-

proceeded from any Elasticity in it; since, it might more probably proceed from the Elasticity of the Air lodg'd in the Pores of the Water. And to make it probable, that those Bubbles proceeded from small Particles of Air, dispers'd through the Pores of the Water, and not from any spirituous Parts of the Liquor expanded, I shall subjoyn the following Experiment.

EXPERIMENT XXII.

The Bubbles prov'd to be Aerious, and not Watery, by observing the like Bubbles in Mercury: To which is subjoyn'd a Digression, whether the Air is generated de Novo, &c.

THO' it be generally alledg'd, that the Bubbles which rise in the Cylindrical Tube, in the foregoing Nineteenth Experiment, are Particles of Water expanded, upon a Diminution of the Incumbent Weight of the Air; Yet I am apter to believe them really Parts of Air dispers'd through the Water; because, upon the re-entring of the Air, the Water was not impell'd quite to the Top, but was depress'd, by the Air lodg'd above it, almost an Inch, which, being collected together, was able to resist the Pressure of the Air.

But in order to a further Discovery, whether the aforesaid Bubbles were Water or not? We try'd the Nineteenth Experiment in a small Receiver, and upon drawing out the Air, the Water subsided; upon which, several Bubbles rising to the Top of the Cylinder, prevented the Rising of the Water, half an Inch, being possess'd

The Bubbles which rise in Water, Aerial, proved.

possess'd by the Bubbles of the Air, collected at the Top of the Cylinder : And we were further perswaded, that those Bubbles were Aerial, because the Air, being a second time exhausted, the Water contain'd in the Tube, was, by the Spring of that *Air* contain'd in the Cylinder, depress'd below the Surface of the Water which was without the Tube, having a Convex Superficies, as Water expos'd to *Air* in such Tubes usually hath, but rather more protuberant : And to demonstrate, that those Bubbles were really made up of Aerial Particles, when the Air was almost exhausted, and the Water had subsided near as low as the external Water, by applying Water to the Tube, which contain'd the *Air*, we observ'd that it was so far expanded, as to depress the Water down to the Bottom of the Tube, several Inches below the External Water : So that the *Air*, which was before expanded to near a hundred times it's extent, was capable of being further expanded by Heat.

But I was yet further confirm'd in my Opinion, that those Bubbles were nothing but *Air*, lodg'd in the Pores of the Water, because the Air being exhausted out of the Receiver, the subsiding Water yielded not Bubbles as before, except a few small ones, when it was near pump'd out. And what I took for a stronger Argument was, that the same Experiment being try'd with Mercury, several Bubbles likewise rose to the Top of the Cylinder ; and the Mercury subsiding a second time, upon the Exsuction of the Air, several Bubbles appear'd in the Bottom of the Cylinder ; which grew bigger and bigger as the Surface of the Mercury descended lower. From whence

whence it appear'd, that a Body, more ponderous than Water, might contain Aerial Particles in it's Pores, capable of expanding themselves, when the Cause of their Compression is taken away; so that we have Reason to believe, that the Intumescence of the Water, not only in these Experiments, but also the ~~increase~~ of the Water, contain'd in the Pewter Globe before mention'd, proceeded from the Expansion of the Aerial Particles contain'd in the Pores of the Water, rather than from any Elasticity in the Water it self.

The Expansion of Water depends on the Elasticity of the Air lodg'd in its Pores.

These things being premis'd, it would be a Matter of some Importance, and of no small Consequence, to determine, whether what we have said of the Air be true, to consider whether Air be really a Primogenial Body, and inconvertible into Water, and *Vice versa*, or not: But it being as difficult, as requisite, we shall rather chuse to offer what may be urg'd of either the Affirmative or the Negative.

Whether Air be a primogenial body or not?

And first, in favour of the inaptitude of Air to be turn'd into Water, or of Water into Air, it may be urg'd; that besides, that it hath been the Opinion of several Philosophers, it hath likewise been found impossible by Experience to effect such a Change in either of them; And the diligent Schottus *Mechan. Hydraulicopneumat. Part 3. Class. 1.* relates, that in the *Musæum Kircherianum*, Water hath been hermetically seal'd in a Glass with a long Neck, and kept there this forty Years, without undergoing any Change: Nor, indeed, do we perceive the least alteration in the Nature of Air, Hermetically seal'd in Glasses for Chymical Uses, tho' it may acquire several Degrees of Heat in them: And it may very plainly

plainly be seen, that tho' Water is divided into smaller Parts, and rais'd in the form of Vapours, by Heat; yet it is so far from being turn'd into Air, that in Chymical Distillations, it falls down into the Receiver in the form of a Liquor. And likewise Volatile Spirits and Salts, tho' their Parts swim up and down in the Receiver for some time, yet the former presently condense into a Liquor, and the latter, into Salts.

And further it may again be urg'd, that tho' the Parts of Water may be put in such an Agitation, as in some measure to counterfeit the form of Air, yet since the quick Coalition of those Parts into a fluid Form, argues the impossibility of giving them a due Texture, requisite to add to Air the Springiness observable in it; it is a strong Argument against the Possibility of effecting such a Change. And that a bare Motion and Agitation of Parts is not sufficient to add Springiness to a Body, appears from the foregoing Experiment concerning a piece of Match, included in our Receiver; where the Agitated Parts of Smoak, were by no means capable of hindering the Expansion of the Bladder contain'd in it.

And tho' *Josephus Acosta* tells us, that Grates of Iron have been so much corroded in the Air, as to be turn'd into a Substance which would crumble into Powder like parched Straw; and tho' the Accurate *Varenius* hath observ'd in the *Iffands* call'd *Azores*, that by the Sharpness of the Air even the Tiles of the Houses have been corroded; yet are they no Arguments, that such corrosive Humors may put on the form of Air;
since

since such *Phænomena* may be accounted for, by the Mixture of corrosive Steams mix'd with it; which are so far from being endow'd with the true Qualities of Air, that they may, notwithstanding they are mix'd with the Air, retain their own Natures; which is evident in subliming of *Sal Armoniack*. And I have had a subtle Saline Body, which would not only rise it self, retaining it's own Nature, but would also raise the Substance of Gold along with it, whose Parts would also retain their own Natures, and stick to the Top of the Receiver like pure Gold.

I remember that once having ty'd a Bladder to the Neck of an *Æolipile*, when the Water was forc'd out into it, so as to distend it, we slip'd it off, and having ty'd it close, put it into our Receiver; where we observ'd, that upon the Exsuction of the Air, it was considerably expanded: And tho' the Bladder, when taken out of the Receiver, continu'd in the Cold for some time; yet the included Substance continu'd near as fully distended: But notwithstanding the Plausibleness of this Experiment, I could not but suspect, that the Distension rather proceeded from the Air, which upon the first working of the *Æolipile* came out with it, than from any parts of the Water converted into Air.

But to proceed to what may be alledg'd, to Countenance the Change of Water into Air; If a good *Æolipile* be plac'd upon hot Coals, the Water will sometimes spring three or four foot high into the Air; and when taken off the fire, will continue to emit copious Streams: And if, when it is taken from the fire, almost empty, the Neck be immers'd in Water, as soon

as it begins to suck in Water, it will raise Store of Bubbles, which seem to proceed from Water too much expanded by the Heat of the *Æolipile*; and if, when that *Æolipile* is almost full of Water, a live Coal be held before the Neck, it will manifestly be kindled, by very vehement Steams which flow out of it, which will have the more powerful Effects, the nearer the Coal is held to the Mouth of the *Æolipile*.

See Figure
the 15th.

But since by holding a Knife before these Steams, they will be condensed upon it into Water; and thence appear not so much to have acquir'd the Nature of Air as to have their Parts put into a violent Motion, I shall add a Relation from the Industrious Kircher, of a Famous Hydraulick Engine, which he made by the Order of Innocent the Tenth. The Account of it, in his own Words, is the following, *Cum eodem tempore quo hac scripsi, Summi Pont. Innocentii X. Mandato Organi Hydraulici in Horto Quirinali constituendi Cura mihi commendata esset, Æoliam Cameram insigni sane Successu construi jussimus, ea qua sequitur Ratione.*

Erat Longitudo seu Altitudo Camera (A H) quinque Pedum, Latitudine tres fere ex Lateribus, constructa, in Medio duo continebat Diaphragmata (C D) & (E F) in Modum Cribri pluribus Foraminibus pertusi. Paulò infra Canalis (G) Aquam advehens inferebatur in (H) eidem Epistomium parabat Exitum. Aqua itaq; per Canalem (G) maximo Impetu ruens vehementissimum Ventum mox intus excitabat; qui Ventus nimis Humiditate imbutus, ut purior exiret siccioreq; Diaphragmata illa in Cribri Modum pertusa, ordinata sunt. Infra
hæc

*hec enim Aqua vehemens Agitatio, rupta fractaq;
Aerem puriorem per Canalem (A) subtiliorem e-
mittebat: Verum cum postea inventum sit Aerem
plus aquo humidum interioribus Organi Meatibus
maximum Detrimentum inferre: Hinc, ut Aer
aquosus siccissimam Consistentiam acquireret, ordi-
navimus Canalem plumbeum (Q R) in Helicem
conformatum Vasi (S) aliquantulum capaciorem in
modum Urnae efformato, insertum. Intra Urnam
enim plumbeam & Canalem tortuosum illis Aer
humidus, ita ab omni Aquositate defacabatur ut ex
Furno in Organum derivatus dici potuerit. Urna
(S) Canalis tortuosus (Q R) ultimum Orificium
(Z) inseritur Anemotheca Organi. Et hunc Mo-
dum Organis Hydraulicis omnium aptissimum re-
peri.*

And I rather cite this Account, because it is deliver'd as Kircher's own Observation; and had I, when I was at Rome, taken notice of these Engines; and found that the *Effluvia* which blew the Organs, were not again condensed into Water, I should be apt to believe it not impossible to turn Water into Air; it being altogether impossible, That the Air lodg'd in the Pores of the Water, should supply so large a Quantity of Air, as is requisite to blow the Organs: I therefore was induc'd to think, that it might proceed from some Parts of the Water put into a very brisk Motion, since I had observ'd, as I pass'd betwixt *Lyons* and *Geneva*, that the River of *Rhone*, being on a sudden straitned betwixt two Rocks, which are so near, that a Man may stand with one Foot upon one, and the other Foot upon the other, some Parts of the Water were put into
so

so violent a Motion, as to be rais'd into the Air a considerable Height; and at a distance to appear like a Mist; tho' I must confess it difficult to conceive, how such Vapours should pass through a leaden Pipe of such a Length, since we see that Vapours are condensed into Liquids, in a much less time, in the Heads of Alembicks, and the Necks of *Aolipiles*, when once the Motion of their Parts are checked by Cold.

But leaving this plausible, tho' not satisfactory Experiment, I shall proceed to another, which is this; Having filled a Glass Bubble, capable of containing about three Ounces, with near equal Parts of Oyl of Vitriol and Water, half a dozen Iron Nails being cast into it, we stopp'd the Cylindrical Neck of the Tube with Diapalma, so close, as to exclude the Air altogether; which being done, we immers'd the Neck of this Bubble into a Glass Vessel full of the same Liquor, and in a little time perceiv'd Bubbles to rise to the Top of it, being rais'd by the Heat produced by the Action of the Oyl upon the Nails; and this Air was so much increas'd, in a little time, as to depress the Water quite out of the Bubble into the Cylindrical Neck of it: But lest that Pressure should be thought to proceed from the Agitation of those insensible Parts of Matter, we observ'd, That tho' the Vessels were expos'd to the Air for four days, to give the Motion of the Parts time to cease, had the Effect proceeded from them; we observ'd, That the Liquor, all that time, continued depressed, the Space beforementioned being filled with Air. And, what was worthy to be noted, Upon a small degree of Heat

Heat approaching the Bubble, the included Air was further dilated: And the like *Phænomena* succeeded upon a Tryal with Nails corroded in *Acqua fortis*; From which Experiments; it might be inferred, That if Water be not convertible into Air; yet it seems probable that it may be generated anew.

And that Air and Water are mutually convertible into each other might further be urg'd, is nothing but what the *Aristotelians* teach and allow of. But we shall rather urge, That if what *Democritus*, *Lucippus* and *Epicurus*, together with other Naturalists teach be allow'd of, viz. That the Qualities of Bodies depend on the different Figures, Shapes and Textures of the Parts of Matter, they consist of; it will be reasonable enough to think, That the Texture of the Parts of Water being alter'd, they may acquire the several Qualities of Air; since it is certain, That the Parts of Matter may, by a lucky Concourfe of Causes, become springy: So Silver by being beaten with a Hammer acquires Springiness, which it loses by being heated in the Fire, and becomes flexible.

EXPERIMENT XXIII.

IN Prosecution of what was deliver'd in the foregoing Experiments, We fill'd a Glass call'd a Philosophical Egg with common Water, about a Foot and a half high; it being large enough to contain about nine Ounces, and the Diameter of the Neck being, at the Top, half an Inch, and at the Bottom an Inch; this being put into the Receiver, and the Pump ply'd, when

when the Air was pretty well exhausted, several Bubbles rose to the Top and broke; but all of them finding an easy Passage through the Water, did not elevate it as when they ascended in a narrower Cylinder; but upon an Admission of Air into the Receiver again, the Water was sensibly depressed.

To try whether distilled Water was more subject to expand than common Water; I put two Ounces of it into a Glass Bubble, which wrought to the Middle of it's Neck; but it neither swelled nor yielded Bubbles upon an Exsuction of the Air.

But having put distilled Water into two distinct Philosophical Eggs, the Neck of the former being straitned with a Glass Tube, we plac'd them in the Receiver, and found a manifest Difference upon the Exsuction of the Air; for in that which was straitned, the Air manifestly elevating the Water, several Bubbles were gather'd about the bottom of the Glass Tube; whereas in the other Egg, the Water was not in the least elevated; and though the Bubble in the last-mentioned, disappear'd upon the Re-ingress of the Air, those above the Tube continu'd visible, only a little contracted, for a considerable time; the Surface of the Water, which was before elevated, being depressed lower than when first put into the Egg.

And after a days time having again ply'd the Pump, we observ'd, That the Bubbles were so much drawn out before, that we could scarce discern a Bubble in either; but that in which the Cylindrical Tube was plac'd, swell'd the
Breadth

Breadth of a Barly Corn, tho' the other did not; yet, in the former, upon a Re-ingress of Air, it subsided again, and whether that Swelling was caus'd by the Rarefaction of the Water, or the Spring of some latent airy Parts, is not easy to determine.

EXPERIMENT XXIV.

HAVING put Sallad Oyl into a Glass The former Experiments prosecuted with other Liquors. about the Size of a Turkey's Egg, whose Stem was near $\frac{1}{2}$ of an Inch in Diameter, the Liquor reaching up to the Middle of the Stem, we plac'd it in the Receiver, together with the like Vessel fill'd to the same Height with Water; and upon drawing out the Air, the Bubbles were not only more copious than those of the Water, but rose much sooner as well as longer, continuing till the Pumper was quite tired with Pumping; and what was very remarkable in this Experiment was, that when the Oyl was put into the Receiver, before the Receiver could be closed, and the Pump put into Action, it subsided near half an Inch in the Stem.

Having put Oyl of Turpentine into a Glass Bubble, we observ'd, That it afforded a good Quantity of Bubbles, which expanded themselves in their Ascent, and would sometimes raise the Oyl in the Tube so much as to make it run over.

But besides the foregoing, we try'd the like Experiments with other Liquors, amongst which, a strong Solution of Salt of Tartar afforded very few Bubbles, and those much

later than other Liquors: Spirit of Vinegar likewise yielded very few: Red Wine afforded Bubbles pretty plentifully, which chang'd Places by moving in an oblique Ascent, and formed a sort of Froth near the Top, which presently disappear'd: Milk afforded plentiful Bubbles, which elevated that Liquor more than common Water.

We likewise put Eggs into the Receiver, to see whether the Substance contain'd in the Shells would break them; leaving the Film within it whole, as that Substance frozen had done; but it succeeded not.

We put Spirit of Urine into a Glass Egg, filling another up to the Middle of the Neck with common Water; to which we added as much Spirit of Wine as rais'd it half an Inch higher; and into a Glass which differ'd from the former only in having a flat Bottom, we pour'd rectify'd Spirit of Wine, till it rose to $\frac{1}{2}$ of the Neck: And the Edges of these three being mark'd, we put them into a Receiver. Upon the Exsuction of the Air the Mixture of Water and Spirit of Wine afforded very few Bubbles: The Spirit of Urine swell'd near an Inch and a half above the Mark, affording Store of Bubbles, which formed a Froth, upon which several larger Bubbles lay, which were plac'd one above another, to the Top of the Tube: The Spirit of Wine afforded Bubbles till we were weary of pumping, which ascended very swiftly, and immediately disappear'd at the Top, first lifting up the Surface of that spirituous Liquor so as to form a thin Film. And it was further observable, That the Motion of these

these Bubbles in their Ascent, was in a strait Line; whereas those of the Water and Wine made a Line, which on each side appear'd like the Teeth of a Saw: And lastly, in this Spirit we took Notice, That the order which these Bubbles ascended in, was in Lines parallel, and of an Equal Distance from each other; the Bubbles likewise following each other, in such an order, as to form a sort of Bracelet, one end of which seem'd to rise from a certain Point at the Bottom of the Glass.

When Air return'd into the Receiver, the Bubbles on the Spirit of Wine gradually subsided; yet neither that, nor the Mixture of Water and Spirit were depress'd below the Mark: But the Spirit of Wine continu'd expanded, near half an Inch, which I found to succeed upon several Tryals.

EXPERIMENT XXV.

HAVING fill'd a Wide-mouth'd Jar, with about half a Pint of Common Water; we sunk two Glass-Viols, whose Shape and Size is represented by the *Eighth Figure*, one of which contain'd just so much of a Ponderous *Mercurial* Mixture, as was requisite to sink it, when cover'd with white Wax; the other being weigh'd down by Water, and the Mouths being downwards; the Quantity of Water contain'd in the former, filling three Parts of four of the Glass, the Air contain'd in the latter being equal in Dimensions to a Pea.

These being let down into the Receiver, upon plying the Pump, at the last so many Bubbles

*Concerning
the Air's
Gravity,
and Expansion
under
Water.*

rose up to that which swam upon the Water, as were able, by expanding themselves, to cause some of the Water to fly out, and make the Viol emerge to the Top of the Water contain'd in the Jar; where at every Exsuction it continu'd to expand, till it was able to raise up the side of the Viol, and in part to evacuate it self; upon which it presently swam upon the Water, as before, and eight times after discharg'd a Bubble of Air about the Size of a Pea; but, when we permitted the Air to enter in again, it presently subsided to the Bottom. As for the other, it continu'd at the Bottom all the while. But some time after, the Pump being ply'd, it rais'd it self considerably; but about sixty Parcels of Air as big as Peas, finding vent, and getting out, it presently subsided; tho' upon a further Expansion of the Air, it rose again, and subsided, which successive Ascent and descent, it continu'd Nine times after after the Pump ceas'd working; but when the Air was again let in, it was presently fix'd at the Bottom. From which *Experiment*, that *Hydrostatical Rule*, That a Body will swim in the Water, if it be lighter than its equal Proportion in Bulk, will appear to be likewise true, when the Weight of the *Atmosphere* is taken off.

EXPERIMENT XXVI.

Concerning
the Vibrations of a
Pendulum.

IT being usually taught, That the Motion of a Pendulum is something quicker, accordingly as the *Medium* it moves in, is thinner; we suspended one, which weigh'd about twenty Drachms in our Receiver, fixing it to the Cover by

by a piece of Silk; and having fix'd another of an equal weight without the Receiver, we gave them both an equal Motion, and observ'd, that whilst the Latter made twenty Vibrations, the Former counted twenty; but the Pendulum, being afterwards put into Motion in the exhausted Receiver, and likewise in the same Receiver, before it was exhausted, continu'd it's Vibrations to an equal space of Time in both; so that from what we could observe, the Difference of the Vibrations in Air, and that more rarify'd *Medium*, viz. the exhausted Receiver, was scarce sensible.

EXPERIMENT XXVII.

IT hath been the receiv'd Opinion of the Schools, That the Air is the *Medium*, through which Sounds are convey'd: But the Industrious Kircher having observ'd, that if a Bell be fix'd in the upper end of a Tube, and, upon making the *Experiment de Vacuo*, be left there, a *Load-stone* apply'd to the side of the Tube, will attract the Steel-clapper; which, upon a Removal of that *Load-stone*, will fall upon the other side of the Bell, and cause an Audible Sound: He thence infers, That the *Medium* through which Sounds are convey'd, must be much more subtle than the Air. But to evince the contrary, we suspended a Watch in our Receiver, by a Packthread, and observ'd, That the Sound was not only audible at the sides of the Receiver; but that that which was likewise perceiv'd by the Ear, held near the Cover, was different from that which we heard at the sides of the Receiver; but the

*Concerning
the Propagation of
Sounds.*

Air being drawn out, we could not perceive the least Sound; tho' the Motion of the Minutes assur'd us, that the Pendulum continu'd it's Motion; yet upon admitting of Air again into the Receiver, the Sound was again renew'd; which *Experiment* seems to evince, that the Air is the Chief *Medium*, through which Sounds are convey'd: Yet it is not a little strange, that so slight a Stroke as that of the Pendulum, should give such an Impulse to the Ambient Air, as to enable it to communicate a Motion to the sides of the Receiver, strong enough to put the External Air into an Undulating Motion.

But having supported a Bell in the Middle of our Receiver, by a large Stick, which reach'd from one side to the other, the Diameter of the Bell, being about two Inches, we observ'd, that tho' the Sound in the Receiver, was not equally as sharp as in the open Air; yet there was no considerable Variation, when the Air was drawn out; which evinces, that a subtler *Medium* than the Air, is not altogether incapable of propagating Sounds, no more than Air; however, in the foregoing *Experiment* try'd with a Bell, suspended in a Glas-Tube, it may not without Reason be suspected, that the Cavity of the Tube was not wholly void of Air, since Experience informs us, that it is impossible to fill the Glas-Cylinder, so as to keep the Upper Part of the Tube void of Air, since the Aery Parts lodg'd in the Pores of the *Mercury*, fly up into it.

And further on this Occasion, to shew how far the Air is the Principal *Medium* of Sounds, we might alledge, that it was observable in a former

former *Experiment*, that tho' upon the striking of Fire, with the Lock of a Pistol in our Receiver, the Sound is audible; yet it is much more dead, than when made in the open Air: And the like Variation is observable in all other Sounds made in our Receiver.

EXPERIMENT XXVIII.

FOR a further Confirmation of what hath been deliver'd in the XXth *Experiment*, viz. The Eruption of Bubbles from Water, upon the removal of the Air. That the Air included in our Receiver, makes as strong a Pressure upon Bodies encompass'd by it, as if they were expos'd to the Pressure of the Atmosphere; we put a Viol, fill'd with Water, and well stopp'd, into our Receiver; and, upon an Exsuction of the Air, found no sensible Alterations; but another, which was not so close stopp'd, being put in, we observ'd that the Air included in the Bottle, upon the Surface of the Water, making it's way out, several Bubbles presently appear'd in the Bottom of the Water: from which Tryals, it appears, That whilst the Air was included, the Water appear'd as if press'd upon by the Atmosphere. But in order to a further Prosecution of our Design in this *Experiment*, we fill'd a Glass-Egg with Water, and suspended it by a String to the Cover; so that, by turning the Glass-stopper in the middle of the Cover, we so screw'd up the Neck of the Egg, as to break it, and thereby make way for the Exclusion of the Air; upon which a number of Bubbles presently rose in the Water, so as to represent a Shower of Rain inverted. But this *Experiment* may be try'd with less trouble, in one of

of our little Receivers, where the Exsuction of the Air is more expeditious. In one of which the *Experiment* being made with red Wine, instead of Water, it appear'd immediately frothy, like Bottle-Ale, tho' open'd less cautiously.

EXPERIMENT XXIX.

*The reason
of the A-
scend of
Fumes and
Vapors.*

TO shew, whether the Ascent of Fumes and Vapours, was rather promoted by the Ambient Pressure of the Air, than that their Ascent depended on their own Positive Lightness; I convey'd a Certain Liquor which I had formerly made for other Purposes, into our Receiver; it consisting of Metalline Ingredients, which upon Unstopping of the Bottle, would emit copious Steams, like the Powder of *Alabaster*; but upon stopping of it again, the Upper Part of the Bottle, as well as the Liquor, became Transparent; and this Liquor being convey'd into our Receiver, with a Weight affix'd to the bottom of the Viol, to keep it from rising up, when the Cork was pull'd out, we ty'd a String to the Cork, and the other End to the Receiver; and having clos'd it up, and pump'd out the Air, we screw'd the Cork out of the Bottle, and observ'd, that tho' some Parts of the Air included in the Bottle, rais'd a few; yet the Fumes did not rise as when expos'd to the open Air, but lifting up themselves by their own Agitation, rose to the Top of the Viol, and no higher, but ran down the outside of the Glass in Streams; which continued till the Ingress of Air was permitted to put a stop to that *Phænomenon*; but as soon as the Bottle was taken out into the open

open Air, Fumes plentifully rose as before: From whence it appears, that Steams in a *Medium* thinner than themselves, may tend downwards.

EXPERIMENT XXX.

TO shew how much the Ambient *Atmosphere*, emulates the Nature of a fluid Body; We enclos'd a light Match, in our little Receivers; and when it was fill'd with Smoak, we took the Match out, leaving the Smoak behind, closing the Receiver again, to keep it from flying away; upon which, we observ'd, That the Smoak settling, it self in, the lower Part of the Receiver, so far emulated a Fluid, as to change it's *Horizontal Superficies*, as the Glass was variously inclin'd. As also upon a more violent Agitation of the Vessel, it was put into a Vibrating and Undulating Motion, as Liquids usually are, which it lost again by degrees. When the Key of the Stop-cock was turn'd, Part of it would flow out like Red Wine, out of a Bottle, when the Neck is inverted and immers'd in Water; the Air gradually ascending into the Receiver in it's Room: Besides which *Phænomena* it was remarkable, that a hot Iron being held near one side of the Vessel; the Smoak was presently rais'd in a Stream up to the Top of the Receiver, keeping distinct Superficies, from the Air included in the Receiver, yet nevertheless upon a Recess of that Heat, it would again subside. And these things being consider'd, as likewise that there is a manifest Difference in the Weight of Proportionable Quantities, as to Extension, of other Liquors, it

The Nature of Fluid Bodies illustrated by Smoak.

it may not be absurd to mention the *Atmosphere*, amongst others Liquids; especially since, besides what we have already taken notice of, we may rationally suppose, that there are several Inequalities upon the Borders of the *Atmosphere*, as well as upon the Surface of that Smoak; since the Inequalities of it's upper Superficies are not altogether indiscernible, if we look upon the Setting-Sun, with a good *Telescope*; for by that means, we may perceive the Surface of it rough, with several Inequalities, which curl along like Waves in the Sea.

EXPERIMENT XXXI.

Concerning
the Cohesion of Flat
Bodies.

TO try the Strength of the Air's Spring, when rarify'd, in a great Measure, by Exsuction, in our Receiver; we try'd an Experiment, formerly more fully taken notice of, with two flat polish'd Marbles: For having fasten'd a Weight of about four Ounces to the lower, and wet the flat Superficies of them with Spirit of Wine, to keep the Air from getting betwixt them, we put them into our Receiver, and found that the Spring of the Air, after several Exsuctions, was strong enough to bear up the Understone, and to keep it from falling. And how strong the Cohesion of Flat Bodies may be, we have a Notable Instance related *P. Nic. Zucchius, apud Schot. Part. 1. Mec. Hydraulopneum.* who says, *Fruen lacertorum suorum robur jactanti proposita semel est laminea arca, per ansam in medio extantem apprehensam elevanda è Tabula Marmorea, cui optime congruebat: Tum instantibus amicis maximum utramque admoveus, cum luctatus diu barem removisset,*

movisset, excusavit impotentiam objecta peregrini & potentissimi glutinis Interpositione, quo fortissimè copulante nequireret divelli; donec vidit ab alio per tabulam facillimè laminam deduci, & ad extrema productionem, & actam in transversum inde deportari. But to make it evident, that two Bodies may stick together, by having their Surfaces Contiguous only in a small Compass, I shall subjoyn an Experiment made in our Receiver.

E X P E R I M E N T XXXII.

HAVING exhausted our Receiver, and taken it off the Pump, we apply'd a tapering Valve of Brass, such as the *Ninth Figure* represents, the taper End being put into the Orifice of it, and the Chink betwixt the Stop-cock and the Glass, being fill'd up with *Diachylon*. To the lower Superficies of the Door of that Valve, was fix'd a Button, to which a Scale was hung, to hold Weights in; and then, the Key of the Stop-cock being turn'd, the *Atmosphere* made such a strong Pressure to get in, as to keep the Valve close to the Orifice, till a considerable Weight was put into the Scales; and then the Weight of the *Atmosphere* being overpower'd, it was presently drawn down. In which Experiment it was to be observ'd, That tho' the Receiver was but moderately exhausted, and tho' it leak'd considerably; yet the Weight supported by the Pressure of the *Atmosphere*, amounted to ten Pound: Nor indeed is it strange, that it's Pressure should be so considerable, if we do but think, how large the Cylinder of Air, that recoiling from the Ground,

The Pressure of the outward Air, on a Valve fix'd to the External Orifice of the Stop-cock.

Ground, presses against it, is, being extended to the utmost Superficies of the *Atmosphere*.

EXPERIMENT XXXIII.

Concerning the Pressure of the Air against the lower superficies of the Sucker, what Weight will draw it down, and how much it is able to raise. A Discourse concerning the Nature of Suction, &c.

*The weight
of the At-
mosphere
consider'd.*

TO compute more exactly the Weight of the Incumbent *Atmosphere*, we impell'd the Cylinder to the Top of the Pump, taking off the Receiver, and fixing just such a Weight to one of the Teeth of the Sucker, as was able to bring it down to the Bottom of the Cylinder; which being done, and the Sucker impell'd up again to the Top of the Cylinder, the upper Orifice of it was exactly stopp'd; and a pair of Scales being fix'd to the Iron-Sucker, by casting in so many Weights, as were able to draw down the Sucker, we were truly inform'd of the Weight of a Pillar of the *Atmosphere* of an equal Diameter with the Bore of the Cylinder. By which Method we found, that the Sucker, which requir'd 28 Pound of Lead to draw it down, was not drawn down with less than the Addition of an hundred Pound, when the upper Orifice of the Cylinder was stopp'd; tho' upon turning of the Key of the Stop-cock, and letting in Air, it would readily fall without that Weight; which was an Argument, that the Descent was hinder'd by the Pressure of the Air, which buoy'd up against the lower Part of the Sucker.

This

This *Experiment* being try'd, and the Sucker being forcibly drawn down to the Bottom of the Cylinder, whose Diameter was about three Inches; the Pressure of the *Atmosphere* was so considerable, as to be able to raise above a hundred Pound weight; besides the weight of the Sucker, which was not a little admir'd by the Standers-by, because they saw no Force used to lift it up.

And tho' by such Tryals we may not be able to discover exactly the weight of the *Atmosphere*; yet, as a Famous Poet says,

Est quoddam prodire tenus, si non datur ultra.

But were this *Experiment* Try'd at several Seasons, in the Year, and in several Climes, as well as in Cylinders of a different Diameter, it might render our Guesses more certain as to the Height, and Gravity of the *Atmosphere*, and whether it varies considerably at such distant times: For the Place where the Foregoing *Experiment* was try'd, was about 51 Degrees Latitude, being try'd in the *Winter*, and about the Change of the *Month*.

But, not to spend so much time, as would be taken up with all the Reflections, that might be made on the Foregoing *Experiment*; I shall consider some few Inferences, which may be drawn from them.

And First, From the Rising of the Sucker, and the Weights fix'd to it, we may call in Question, what some teach concerning Suction, viz. That there is a sort of Endeavour, to draw the Body suck'd, in the Parts of that Body which is said to

to suck; for tho' when we suck a thing with our Mouths, there is a Manifest Endeavour of our Mouth to draw the Body suck'd; yet the Cavity of the Cylinder is not so dispos'd by any Endeavour in the Glass-Tube. Nor can the Ascent of the Sucker be attributed to any sucking Force of every Part included in the upper Part of the Cylinder, since it appears not, how such Aery Particles should be hook'd in the Pores of the Sucker, or how they should be able to raise such a Weight: Nay, that those Particles of Air do not draw it up, is further evident; since by admitting more Air in, that supposititious sucking Quality is diminish'd, and not increas'd: And for the same Reason it is evident, that it cannot proceed from a *suga Vacui*; for there is the same Reason for an Endeavour to prevent a *Vacuum*, tho' a little more Air be let in, as there was before; since there still remains a *Vacuity*. Nor can the weaken'd Attraction, upon letting in of Air, be attributed to the Resistance of the *Vacuity*, but rather the Spring of the included Air; since when in the former *Experiment* it was plain, that the rising of the Sucker and Weights, was not obstructed by the Cavity of the Cylinder, when void of Air.

Considerations concerning a Vacuum.

But to proceed: From hence further we may be directed, what to think of *Nature's* Abhorrence of a *Vacuum*, which hath been so long held as an *Axiom* in the Schools: For besides, that the Insensible Parts of Matter, can neither have Sense to perceive any ill consequences in the Universe, which would ensue a *Vacuum*, nor be able to know how as Intelligent Parts of Matter to prevent it; (for if they did, *Nature* may be said in a great many

many Cases to act very irrationally to effect her Designs, since in the XXXII^d Experiment, instead of rushing into the Receiver, she less cautiously rais'd up the Valve, and kept her self out. But, I say, besides the Insensibility of Matter, it may farther be urg'd against that *Axiom*, that the Endeavour which those Bodies may seem to have, rather is to fill than to prevent a *Vacuum*; since upon the drawing down of that Valve, the Air which rush'd in, could not prevent what was already in Being. Besides in our XIXth Experiment, it might be demanded, Why the Water which descended into the Tube, upon the Exsuction of the Air, did not rather keep it's place to prevent a *Vacuum*, or why for the same Reason it did not ascend before the Re-ingress of the Air.

Moreover, the Air may rather be said to rush in again, as being impell'd by the Spring of the Neighbouring Air, than a Design to fill the Vacuities, since from our XVIIth Experiment, it appears, That when the Receiver was suppos'd to be full, we could by the help of the Sucker, find the Spring of Subsequent Air impell'd by it, still force more into it; and even in Wind-Guns it is manifest, that the Air compress'd as much as it is in our Receiver, may be squeez'd into half the Room.

And from the foremention'd Experiments, it may further be deduc'd, That the Reason, why *Metaphorically* speaking, Bodies may seem to forget their own Natures, to shun a *Vacuum*, seems to consist in this, *viz.* that the Weight of the incumbent Water, or the Pressure of the subjacent Air were not strong enough to press down or buoy up one another; for from our Nineteenth

Experiment it appear'd, that when the Pressure of the Air was taken away, the Weight of the Water it self was sufficient to make it subside, tho it left no Air behind it: But further, from this last mention'd Experiment it appears, that it is possible, Even by Weights, to measure how far Nature is dispos'd to prevent or fill Vacuities; since a small difference in Weight determin'd, by depressing or permitting the Sucker to rise, how far Nature's Abhorrency of a *Vacuum* depended on the Causes we have so often mention'd.

But here it may be requisite to advertise, that by Vacuities, I do not mean Spaces altogether void of Matter, but void of such as may be perceiv'd; so that I take the Word *Vacuum* in the Common, not the strict and Philosophical Sense of the Word.

But lastly, from this XXXIII Experiment it appears, that the Weight of the *Atmosphere* we live in, is stronger than what Men usually think it is; And probably, near the *Northern Pole*, it is much stronger: Since, if what *Varenius* observes, the Air is so condens'd in *Nova Zembla*, as to hinder the Motion of a *Pendulum*, except moved by a heavier Weight than what is usually made use of in our Climate.

EXPERIMENT XXXIV.

*Attempts
to weigh
light Bodies
in our Re-
ceiver.*

TO try whether the *Equilibrium* of two Bodies, of an equal Weight in the Air, but of unequal Dimensions, would be lost in our Receiver, as it usually is in Water, by Reason of a greater Quantity of Water buoying up against

gainst that whose Dimensions are most extensive, I took a Bladder half full of Air, and ty'd it to one end of our Balance, which turns with the 32 part of a Grain; which being counterpois'd with a Weight in the other Scale, we let it down into the Receiver, and having clos'd it up, upon an Exsuction of the Air, we found the Bladder to dilate and manifestly to preponderate; but upon admitting the Air into the Receiver again, the Bladder was over-pois'd by the Weight; but leaving them in the Receiver all night, the Bladder imbib'd so much of the External Moisture, as to weigh that end of the Balance down a good way; yet the Bladder being dry'd a little, they were both brought to an *Equilibrium*: And the like Experiment we try'd with a piece of Cork instead of the Bladder, and observ'd, that, the Receiver being Evacuated, as well as upon a reingress of the Air, the Cork manifestly preponderated.

EXPERIMENT XXXV.

Of the Cause of Filtration, and the Rising of Water in the Syphons, &c.

TO try whether in Filtrations the rising of The Cause of Filtration, the Water might not proceed from the impulse of the Air; we made use of a Syphon of Glass, represented by the *Third Figure*, which is made of two strait Pieces, and a crooked one, which joins the other two together, the Junc-tures being well clos'd. The longer Leg of the Syphon was pervious only at the small End, so as to suffer the Water to pass through it; but

both the ends of the shorter Leg were equally pervious, the Diameter of their Bore being $\frac{1}{4}$ of an Inch. The length of these two Pipes was about a Foot and a half, that the Rarifi'd Air in the Receiver, when it was pretty well exhausted, might not raise the Water included in the Pipe too high. The shorter Leg of the Syphon being immers'd two or three Inches in a Vessel of Water, the other end was fastned to the Cover; which things being done, and the Receiver clos'd up, we began to pump. The Result of which was, that the Water dropp'd out of the lower Leg of the Syphon, as if it had been expos'd to the open Air; till the Receiver was in some measure exhausted, and then several Bubbles rising in the Water, gather'd together at the Top of the short leg'd Syphon, where expanding themselves, they stopp'd the Course of the Water; that in the longer Leg being suspended in the Tube and ceasing to drop; and the Water in the shorter Leg, was so far depress'd, as not to be above a Foot high: But as soon as the External Air was let in again, it enter'd in at the small Orifice of the longer Tube; and, ascending through the Water contain'd in the Pipe, joyn'd with the former, which was lodg'd in the upper Part of the short leg'd Tube.

But, to prevent what Inconveniencies ensu'd the rising of these Bubbles, the two foremention'd Tubes, were placed so, as to meet in the middle of a Glafs Viol, the Neck of the Viol being clos'd up with Cement; and the Tubes being thus fix'd, and they, as well as the Viol, fill'd with Water, the Syphon represented by the *Fifth Figure* was plac'd in the Receiver with its shorter

shorter Leg in a Vessel of Water, upon which the Pump being ply'd, the longer Syphon continu'd to drop much longer than before; but at the last, the Bubbles which rose in the Pipes, were so dilated in the Viol, as to press down into the Ends of the Tube, and interrupt our Experiment, tho' what we observ'd gave us Reason to believe, that the Air contributed to the Motion of the Water through the Syphons.

And here, I shall subjoyn, that I once had a very slender Pipe, which when held upon the Surface of the Water in a Perpendicular Posture, the Incumbent *Atmosphere* press'd so much more on the Surface of the External Water, than that contain'd in the Tube, that the Water was rais'd in the Tube; and this Pipe being bent into a Syphon, and plac'd with the shorter Leg in Water as Syphons usually are, the Water, of its own accord, rose in the shorter Leg, and ran down the other; and this Syphon being plac'd in our Receiver, to try what Alteration of the *Phenomenon* would appear there, we could not discern any sensible one. But tho' in this Tube just now mention'd, the Water rises of its own accord; yet, if such a Tube be thrust a little way into the Mercury, instead of rising, the Mercury in the Tube will be below that which is without it.

E X P E R I M E N T XXXVI.

The Weight of Air in the Exhausted Receiver. The subtle penetrating Power of some Spirits above that of the Air. The Cause why Air will not enter the Pores of some Bodies which Water will. The Weight of the Air, examin'd by an Æolipile. The Proportion betwixt the Gravity of Air and Water: Betwixt Water and Quicksilver. Conjectures concerning the Weight of the Atmosphere.

The Weight of the Air.

Notwithstanding the several Methods propos'd by Galileo, and others, to try the Weight of the Air; being willing to be further satisfi'd, we caus'd an Oval Glass with a small Tube at one End to be blown at the flame of a Lamp. And this Glass Bubble, being of the size of a Hen's Egg, was fix'd to one End of a Balance, being counterpois'd by a Weight at the other End, which being suspended in our Receiver, and the Pump set on work, the Bubble, after three Exsuctions, continu'd to preponderate more and more, till the Air was let in again, and then the Balance was reduced to its former *Æquilibrium*. But having repeated the Experiment with an additional Weight of three Quarters of a Grain, in the Scale opposite to the Bubble, the Weight of the Air included in the Bubble brought the Balance to an *Æquilibrium*, when the Air was drawn out; which *Æquilibrium* was again lost upon a reingress of it; so that had the Air been wholly exhausted, the Air contain'd in the Bubble might probably have

have weigh'd a whole Grain ; and to prove that the Weight of the Air did really depress the Balance to which the Bubble was fix'd, we exhausted the Receiver when the Neck of the Bubble was open ; and did not perceive that End of the Balance in the least to preponderate : But a Lamb's Bladder being equally pois'd with a correspondent Weight, manifestly weigh'd down the Balance, tho the Air included in it, was considerably expanded when the Air was pump'd out of the Receiver.

But once having caus'd the Pump to be ply'd longer than ordinary, the Air contain'd in a Glass Bubble expanded it self so powerfully, as to cause the sides of it to fly in pieces ; which is a strong Argument of the Closeness of the Pores of the Glass, which are too fine to permit the Air to pass through them. And for a further Proof of the imperviousness of Glass, even by so minute Particles as those of the Air, I shall add ; that in all the Tryals I ever made, I but once found that a Spirit whose Parts are much more subtle and volatile than Air ; I say, I but once found that a Spirit drawn from a Substance abounding with volatile Salts, and subtle Spirits, made way through the Pores of the Receiver, which unusual *Phenomenon* probably depended on the brisk Agitation of those spirituous Parts, encreas'd by the more than ordinary Heat with which they were rais'd ; for the Motion of them was so violent, as to fill the Receiver, and almost burst it with their impetuous Steams ; so that the Pores of the Glass being open'd with the violent Heat, several of them

The Penetrating power of some Spirits above that of the Air.

penetrated those Pores, and appear'd on the outside of the Glass.

*Why the
Parts of the
Air are more
indispos'd
to pass
through
the Pores of
some Bodies
than others.*

But tho' by some, the Particles of the Air are thought to be able to penetrate Glass; yet by others, they are thought to be Grosser than Water; since from the following Experiment it appears, that Water is capable of penetrating Bodies, and of being compress'd into their Pores, which Air is not: For having convey'd a small Bubble of Water into the longer Leg of a Syphon, whose Orifice was as small as a Pin, that Air being incapable of passing through so small a Pore, kept the Water above it, suspended in the Tube; but as soon as that Bubble, by blowing into the wider Orifice of the short Leg, was compress'd and squeez'd out, Water pass'd through that small Orifice without any other force than the Weight of that which lay upon it. And the Inability of Air to pass through such Pores, which Water will readily enough, will be further evinc'd, by holding Water in a Tube, the lower End of which being very narrow, and perforated with a Pore no longer than a Hair; for the Water will readily pass through it; but if the Tube be inverted, the Water in the narrower End of that Pipe will be suspended, as if the End were wholly unperforated; the Air not being able to get through so small a Passage. And that Water will pass through Pores, which Air will not, may be further evinc'd, by putting a little *Alkalizate Salt* into a Lamb's Bladder; for by wetting the End of the Bladder on the outside, the Water passing through it's Pores, will presently dissolve that Salt.

But

But to return to what we have hinted before, ^{The force of the Air's Expansion.} concerning the Expansion of Air in a Bubble, so violently, as to break it; the Learn'd Jesuit *Cabani* says, he saw a Pillar so thick, that three Men could not grasp it, and that 1000 Yoke of Oxen could not tear it in Pieces; yet the Air included in the Crannies of it, so violently expanded upon the burning of a Fire near it, that it flew in pieces, tho' the Pillar was made of so solid Stones as Marble. And as for the Reason why sometimes the Bubbles included in our Receiver, did not break as at others, it probably proceeded from the Air's Expansion by Heat, when they were seal'd, the included Air, upon a Removal of that Heat, contracting it self, and losing part of it's Springiness; but this Guess we cannot wholly rely on. But,

To determine more exactly the Weight of the ^{The Weight of the Air.} Air, we heated an *Eolipile* of Copper, as hot as we could conveniently; and removing it from the Fire, we stopp'd the Neck with hard Wax, to keep out the Air; which being Weigh'd, when cold, counterpois'd six Ounces, six Drachms and Thirty nine Grains; but the Air being permitted to rush in, by perforating the Wax with a Needle, the *Eolipile* and Wax balanced an additional Weight of 11 Grains; so that the Weight of so much Air as fill'd the Cavity of it, weigh'd half a Scruple and a Grain. And tho' *Mersenne* affirms, that he had rarifi'd the Air to seventy times its Bulk in an *Eolipile*, yet I must confess it seems impossible to me, except the Metal his were made of, would bear a much greater Degree of Heat, without melting, than ours would, to rarifie, and expel the Air contain'd
in

in them : Besides, the Method he took seems much less exact than ours, since he weigh'd the *Æolipile* whilst hot ; which might throw off a Considerable Quantity of Scales, as we have often observ'd ; the Weight of which, in weighing so light a Body as Air, might be considerable.

Proportion
betwixt the
Weights of
Air and
Water, &c.

As for the Difference in the Weight of an equal proportion of Air and Water, tho' *Ricciolus* and *Galileo* have, by different Methods, made very different Computations ; and *Mersennus* hath asserted it to be as 1300 to 1. Yet by the most accurate Computation we could make in our *Æolipile* the difference appear'd to be, no more than as 1 to 938. I shall not wholly reject what *Mersennus* relates, but rather endeavour to reconcile the Difference, by representing, that my Observations were not only made in this Climate in *London*, where it is much colder than at *Paris* ; but also at a time, when the Air was condens'd by the Winter's Cold ; at which time it may be suppos'd to be a fifth Part heavier than at *Paris*, when *Mersennus* made his Observations. Wherefore it would be of no small use, to make such Observations in several Countries and at several Seasons of the Year.

Conjectures
concerning
the Height
of the At-
mosphere

Having said thus much about the Weight of the Air, it may perhaps be expected, that I should, by the Assistance of the Observations already deliver'd, determine the Height of the *Atmosphere*, from whence the Pressure of the Air proceeds : But tho' it may be no difficult Task to shew, that the Accounts given by others are false ; yet it is not altogether easie to determine a Controversie, in which the Truth is so hard

hard to be assign'd; and therefore, I shall only lay down something in order to the Elucidation of it.

And first, it is necessary to take Notice, that the Weight of an equal Proportion of Air and Water about *London* is agreed on to be as 1000 to 1.

In the next place it will be requisite to consider, the Difference in Weight, of an equal Proportion of Air and Quicksilver; to discover which, I took a Glass Pipe, such as is represented by the *Sixteenth Figure*, which being partly fill'd with Quicksilver, and held in such a Posture, that the Superficies of the Quicksilver in each Leg was in a Horizontal Line, E. F. I pour'd Water into one Leg, till it was fill'd up to the Top, by the Weight of which, the Surface of the *Mercury* was weigh'd down from E. to B. the Surface of the other being rais'd from F. to C. so that measuring the Height of the Tube of *Mercury* D. C. which was buoy'd up by the Water in the other, we found it to amount to $2\frac{1}{2}$ Inches; the Height of the Cylinder of Water B. A. which counterpois'd the *Mercury* being $30\frac{1}{4}$ Inches, and the whole Numbers with the Fractions, being reduc'd to improper Fractions of the same Denomination, the Proportion was as 121 to 1665, or by Reduction, as one to $13\frac{1}{4}$.

Besides this, we took another Method, to discover the Proportion of these two Liquors, by weighing them in a Glass Bubble; by which we found, that it was as 1 to $13\frac{1}{4}$; and because Spirit of Wine is usually esteem'd the lightest of Liquors, and Quicksilver the heaviest, I weigh'd

weigh'd that likewise, and found the Proportion of Quicksilver, and it, to be as 1 to 16 $\frac{41}{100}$. So that the difference betwixt Spirit of Wine and Water was as 1 $\frac{11}{11}$; And here it may be necessary to observe, that I the rather weigh'd these Liquors in a Bubble; because, when they are weigh'd in open Vessels, the Protuberant Surface of the Mercury, and the Concave of the Water, makes it a difficult Matter to proportion them exactly, if the Superficies be large.

*The Weight
of an equal
Proportion
of Air and
Mercury.*

But to return to the Atmosphere. Having laid down the Proportion of Air to Water, and of Water to Quicksilver, it will be no very difficult thing to find, the Proportion betwixt Air and Quicksilver. And since from the Torrecellian Experiment, it appears that the Cylinder of Mercury is buoy'd up by the Pressure of the Air, it consequently follows, that the Proportion of Air to Quicksilver is as 14000 to 1; so that a Cylinder of Air, that is able to buoy up Mercury two Foot and a half, must amount to 35000 Feet of our English Measure, or seven compleat Miles; supposing the Air to be equally compress'd above, as here below; but this Computation is not to be accounted so exact, since not only Seneca Nat. Quaest. lib. 4. cap. 10. says, *Omnis Aer, quo propior est Terris hoc crassior; quemadmodum in Aqua & in omni humore Fex ima est; ita in Aere spississima quaeque desidunt*, but it likewise is a Consequence of the Air's Spring; since it must needs be considerably compress'd by the Weight of what lies upon it; besides, if we consider, that the Air may be expanded by Heat, to near a hundred and fifty times its Bulk, it may not be improbable, but that the utmost extent

tent of the *Atmosphere*, may reach to some Hundreds of Miles.

And this Conjecture may enable us to guess at the Height to which some Vapours may ascend, allowing what *Emanuel Magnen* a diligent Mathematician observ'd at *Toulouse* in a clear Night in *August*; for as *Ricciolus* records it, *Vidit ab Horâ undecimâ post Meridiem usq; ad mediam Noctem Lunâ infra Horizontem positâ, Nubeculam quandam lucidam prope Meridianum fere usq; ad Zenith diffusam, qua consideratis omnibus non poterat nisi à Sole illuminari; ideoq; altior esse debuit tota Umbra Terra:* And the same Author further says, *Addit simile quid evenisse. Michaeli Angelo Riccio apud Sabinos versanti, nempe viro in Mathesi Eruditissimo.*

But to conclude; It would be of no small Use in estimating the Height of the *Atmosphere*, were Observations of the Density and Rarity of the Air made upon several Parts and on high Mountains; but till by some Means or other, we can arrive at some degree of Certainty, as to the various Degrees of it's Rarefaction above, it will be a hard Matter to determine the Height of it.

EXPERIMENT XXXVII.

Concerning Flashes of Light in the Receiver.

AT the first when our Engin was made, we observ'd, upon drawing down the Sucker, and turning the Key, several Flashes of Light in the Receiver; which would not appear, if the Window which fac'd North-ward were

were darkned; and this *Phænomenon* depended on so unknown Causes, that upon often repeated Tryals, I found, that sometimes it would appear and sometimes not; though for as much as I was able to perceive, there was not the least Difference in the Circumstances of these Tryals; which made it difficult to bring our Observations to any Rules about it, or to frame an Hypothesis to Account for the Cause; tho' the Validity of some Conjectures that have been made may be afforded by the following Tryals and Observations. For,

First, We found, That the *Phænomenon* might as well be exhibited by a Candle-light or Day-light, and however situated, so that the Rays of Light could but fall upon the Receiver.

Next, The Flash appears just when the Key is turn'd to let the Air out into the Cylinder; but the same *Phænomenon* would appear in a small one upon drawing the Sucker hastily down, tho' the Key was turn'd before; and it was further to be observ'd, That the Flashes, which appear'd when first the Receiver began to be exhausted, were much stronger than when it was further evacuated.

And it was besides observable, That when the Experiment was made in the small Receiver, and the Sucker had not been long before well oyl'd; the Oyl, upon the drawing of it down, being put into Agitation, and divided into small Parts by the Attrition of the Pump, would rise into the Receiver like Smoak; which would likewise flow out of the Valve, when it was open'd on purpose; and these Fumes, if the Glas was held in a light Place, would in some Measure

Measure appear luminous. And what was further to be admir'd, was, That when the Flash was considerably great, upon the Disappearance of it, the Receiver would become opacous, leaving white Steams upon the internal Superficies of the Receiver.

And now if it should be asked, Whence all these *Phænomena* proceeded? We should propose the following Conjectures, viz. First, That had the *Phænomenon* constantly succeeded, we should have suspected the seeming Light to proceed from some Refractions from the Glass darkned within by those white Steams. Secondly, That, since the Air abounds with Parts gross enough to appear in the Sun-beams, and to reflect the Rays of Light, which rise from Bonfires, the Reflection might proceed from some gross Airy Parts within the Receiver. Thirdly, The Whiteness seem'd to proceed from the various Surfaces of the airy Parts, reflecting one upon another like Looking-glasses, so as to represent each other contiguous; so Water or Eggs beaten to Froth, lose their Transparency, and appear white: But further having immers'd the Neck of our Receiver in Water, and set the Pump on work; the Water being drawn in through a small Hole, had its Parts so broken, that the Receiver appear'd full of Milk rather than Water: And if a Piece of Crystal be thrown very hot into cold Water, it will crack, and having so many new Surfaces within appears white.

Which Things being consider'd and weigh'd, it may not be an improbable Guess, That the aforementioned *Phænomena* proceeded from the Parts of the Air displac'd as to their Posture and Situation,

Situation, as, whilst in that Motion, to disturb their former Continuity and Transparency.

And this Conjecture may be made probable by observing, That the more Air was included, the more conspicuous was the Whiteness; but more especially by this, *viz.* That having exhausted the Receiver, and apply'd a Glass Bubble to the Hole in the Stop-cock, so that there might be a Communication betwixt the Cavity of the Receiver, and it, upon the Exsuction of the Air out of the Receiver, the Air in the Bubble was so disorder'd, by so sudden a Disilition of it's Parts, that it appear'd like Milk; but upon a sudden Re-ingress of the Air, became transparent again.

But if it should be objected, That the Whiteness in Water turn'd into Bubbles may proceed from the Interposition of so Heterogeneous a Body as Air; I should answer, That I have in another Place mentioned two volatile Liquors, which being mix'd produce a white consistent Body, though both the Ingredients were transparent.

But having convey'd some Smoak into our Receiver, and observ'd upon plying of the Pump, That the Air remaining in the Pump, became opacous; we suspected, that the Reason why the former mentioned Light sometimes appear'd and sometimes did not, might proceed from some Parts of Matter swimming in the Air more at one time than another, which was dispos'd more to cause such Reflections of the Rays of Light as to afford the fore-named Phenomenon; which is rendred probable by observing,

observing, That the Receiver appear'd opaque when the Smoak settl'd about the Sides of it; and it may further be illustrated by what we mentioned before of our smoaking Liquor, where the Corpuscles of it being put into a new Motion became opacous instead of transparent.

And if it should be asked, How the Air should abound with such various Parts of Matter? I must answer, That it is not an unusual Observation, That the Air undergoes several and very frequent Changes; for besides several Instances which might be added, the Learned *Josephus Acosta* observes, That in *America*, There are Winds which naturally trouble the Water of the Sea, and make it Green and Black; others, clear as Crystal. Besides we observ'd, That the Pendula as well as Scales suspended in our Receiver, lost a great deal of their Brightness, upon drawing out and letting in the Air. And I once made a Tincture of a certain Metalline Substance, which would become turbid and clear successively, for several times, for which strange *Phenomenon* no Reason could be given.

EXPERIMENT XXXVIII.

HAVING conveyed a Glass Vessel into our Receiver, in the midst of which was contained a Cylinder filled with Water, and enclosed with Snow and Salt, upon plying of the Pump, the Snow began to melt a little faster than we expected; and the Receiver being pretty well exhausted, the Water in the Cylinder began to freeze; so that, in a little time, the Surface of the Ice was above that of the Water,

Of the freezing of Water and its Expansion.

A a

Water,

Water, in which the Snow and Salt was dissolved, and which swam about it. The Surface of the Water was concave, and being held betwixt the Eye and the Light, appear'd full of Bubbles.

And it is not a little strange, That there should be so powerful an Expansion in Water froze, as not only to burst Bottles in the Winter-time, but, as I am inform'd, to separate the solid Parts of Metals; so that Bell-Metal having been expos'd to the Wet, and that Wet froze in the Pores of the Metal, it would fly in Pieces; and *Cabeus* in lib. 4. Meteor. *Aristot.* relates a no less memorable Account of Vessels made of Stone, which would fly asunder, upon the Expansion of the Moisture lodged in their Pores, and froze there. Where it is not a little strange, That Cold should by freezing Water, cause it to swell, whereas the Effect it hath upon the Air is manifestly to condense it.

EXPERIMENT XXXIX.

A Phenomenon taken notice of in the exhausted Receiver.

HAVING put the End of a Glass Tube into an Oval Glass, so that it almost touched the Bottom, we cemented it to the Neck of that Oval, and then, conveying about six Spoons full of Water into the Egg, we blew it so full of Air, as to force the Water into the Pipe, and to keep it suspended betwixt that Air shut up in the Viol and the external Air; this Weather-glass represented by the *Fourteenth Figure*, was plac'd in a small Receiver, at the upper End of the Tube, which was small, being permitted

ted to stand about five Inches above the Cover, the middle of which it penetrated.

Upon pumping out the Air, it was to be observ'd, That the Water in the Pipe manifestly descended; which was an Argument that no Sensible Heat was produced in the Receiver, by the Action of the Pump; since by barely applying my Hand to the outside of the Receiver, that gentle Warmth so far rarify'd the Air in the Egg, as to enable it to raise the Water in the Tube, much higher than it was depress'd, upon the Exclusion of the Air: Tho' we will not thence infer, that the Cavity of the Receiver, was colder after than before the Air was pump'd out; since the Pressure of the Air in the Egg, together with the Weight of the Incumbent *Atmosphere* might, in some measure, cause the sides of the Glas to give way, for want of an equal Pressure of the Air on the Convex, and external Superficies of it; which Guess may seem the more probable, not only because the Springiness of Glas might contribute to the bending of it; but likewise since upon a Re-ingress of Air, the Water was rais'd up to it's former Height again.

But to return to our *Experiment*: From hence it appears, That if there be no *Vacuum* betwixt the concave sides of the Receiver, and the Superficies of the Bubble, every Substance fine enough to penetrate the Pores of Glas, hath not it's Parts in an Agitation, strong enough to produce Heat and Fire.

Besides the Former *Experiment*, having try'd what Effect the Exhausted Receiver, would have on *Camphire*, whose Parts are so fugitive as to fly away when put into Motion, by the Action

of Ambient Air, we found that it was not in the least alter'd.

EXPERIMENT XL.

*Whether
Rarity'd
Air will su-
stain Flying
Insects.*

HAVING convey'd a Flesh-Fly, a Butter-fly, and a Humming-Bee into our Receiver; the former presently dropp'd down from the Place she was walking on; and after a few Exsuctions, the Butter-Fly, which before flutter'd up and down, dropp'd down void of Motion, except a Tremulous one in her Wings. And the Bee in a little time, was wholly depriv'd of Motion: But whether the Falling of them depended on the Thinness of the *Medium*, which was unapt for them to swim in or not, will appear from the following *Experiment*.

EXPERIMENT XLI.

*Concerning
Respiration.*

HAVING convey'd a Lark into our Receiver, and clos'd it up; upon plying the Pump, the Bird presently began to droop, and when the Receiver was further exhausted, being first taken with violent Convulsions, and Tossing up and down the Cavity of the Vessel, it died with it's Back contiguous to the Receiver; it's Head directed down towards the Stop-cock, and it's Neck awry: And tho' at ten Minutes Distance, after this Bird was clos'd up, the Air was again let in at the Stop-cock, yet did it not recover again. And the like succeeded upon inclosing a Hedge-Sparrow, except that the Air being let in again, at the end of seven Minutes, it recover'd by degrees; but when it seem'd

able

able to fly away, the Receiver being again exhausted, it died in five Minutes Time.

Having inclos'd a Mouse in our Receiver, it continu'd to leap up for some Time after the Air began to be exhausted; but in a little Time after that, it appear'd sick and faint, and very giddy, and at the last fell down dead; yet upon a Re-ingress of Air, presently recover'd; but the Air being again pump'd out, in about ten Minutes, it died moderately convulsive. And it was not only observable in this, but all the other *Experiments* of this Nature, that I try'd, that the Included Animals died convulsive.

And to make it appear, that in the Foremention'd Tryals, the Animals died for want of Air, and not by being chok'd up with Fuliginous Recrements; I inclos'd another Mouse in our Receiver, which, the Air not being drawn out, liv'd 3 Quarters of an Hour; but upon pumping out the Air, in ten Minutes, died convulsive. And another being left in all Night, was alive the next Morning, and had eat Cheese, which was, for Tryal's sake put in with him.

A Digression containing some Doubts touching Respiration.

HAVING made these *Experiments* relating to Respiration, it may perhaps be expected that I should say something concerning the Usefulness of Air in Respiration. In doing of which, it is not requisite that I should take Notice of the Structure of those Parts, since they have been sufficiently describ'd already. Nor shall I any further engage in that Controversy, Whether the Motion of the *Lungs* depends on the Motion

of the *Thorax*, or not, or how the *Lungs* are distended by the Air, any further than it may be Illustrated by our *Engin*.

As for the First Part of the Controversy, it seems to be determin'd in favour of the Affirmative, by what the Learned Dr. *Higmore*, and *Bartholinus* have observ'd; the former having taken Notice, That the *Lungs* subside, if the *Intercostal* Muscles be so wounded, as to lay the *Thorax* open; and the latter having observ'd the same upon a Division of the *Diaphragm*: But what it is that conveys the Air into the *Lungs*, is yet undetermin'd; since some think it to proceed from the Dilatation of the *Thorax* impelling the Air contiguous, and what is contiguous to that, successively into the *Lungs*: But this Supposition is fairly answer'd, since it is possible to breathe out of a Glass, where the External Air press'd on by the *Thorax*, can only press on the outside of the Bottle. But a more easy Solution may be taken from our *Engin*, since it appears, That if the *Lungs* be dilated by the *Thorax*, the Spring of the Air is sufficient to force it in, there being less Resistance made by the Rarify'd Air in the *Lungs*, than that in the open *Atmosphere*. And tho' there are some Observations, which testify, that when the *Diaphragm* hath been considerably wounded, without damaging Respiration, yet since the *Lungs* are void of Musculous Parts to dilate themselves, we are rather inclin'd to believe that they are dilated by the Expansion of the *Thorax*, and fill'd by the Gravity, and Pressure of the *Atmosphere*.

But to proceed to the Use of Air in Respiration, besides the Usefulness of it in Modulating sounds,

Sounds, and the Conveying of Odours, it is beyond Doubt, That it is in a great Measure necessary to the Preservation of Life, tho' as to the Manner of it's Contributing to the Continuance of Life, several disagree; since it is by some thought only to keep the Blood from growing too hot in the Ventricles of the Heart. But that this is not all that the Air, in Respiration, performs, is evident, since not only Old People, but several Creatures, have no need of Cooling their Blood and Humours being cold enough without it, yet they cannot live without Respiration.

Others hold that the Air being convey'd into the Left Ventricle of the Heart, contributes to the Generation of Spirits; but since there appears no such Passages, as are fit for it's Conveyance, we shall not here recite what other Arguments might be alledg'd against it.

But others, as *Mabius* and *Gassendus*, are of Opinion, that it chiefly serves to Ventilate and Carry off the Excrement of the Blood; for as a Candle may be extinguish'd by it's own Smoak; so the Heat of the Blood might be prejudic'd, were not it's Fuliginous Recrement carry'd off, by mixing with the Air upon Inspiration. Which is Congruous enough, to what hath been observ'd by several Travellers; viz, That there is a certain Consistence requisite in the Air, to carry off such Fumes; for it is observ'd, That if the Air drawn in, be too much impregnated with Vapours, as in some Cellars, when Dumps arise in Mines, it becomes so unfit to Breathe, as to stifle those that do not avoid the Latter, or use some Method to rarify it, as by holding a Chaffing-dish of Coals near their

their Faces, to disperse and scatter those Fumes. And to confirm these Observations, I shall add, That having clos'd a Bird in our Receiver, I observ'd, that the Air being thicken'd by frequent Respirations, it began in a little time to pant and gape, and at the last grew so sick, as to throw foul Matter off it's Stomach; and in 3 Quarters of an Hour to be ready to die: And that the Receiver should be so fill'd with Steams, needs not seem a Wonder, to any one that considers, what *Sanctorious* hath observ'd, viz. That the greatest Part of our Aliment is carry'd off, by Insensible Transpiration.

And as these Instances shew, how unfit an Air too gross, is for Respiration; so that an Air too thin is likewise prejudicial, appears from the Experiments already try'd in our Receiver; so that it is not Improbable that if a Man were remov'd to the Top of our Atmosphere, he would die for want of Breath.

In favour of which Conjecture, I shall add, That the Learned *Josephus Acosta*, tells us, that going up a high Mountain in *Pernu*, call'd *Pariacaca*, which was so high above the Alps, as to make them appear only as high Towers, he and his Companion were taken with excessive Vomiting, together with Blood, which lasted till he came to a Region more convenient for Respiration; and he likewise says, to our present Purpose, That the Element of the Air is so subtle and delicate there, that it is too fine for a Man to breathe in; the Action of Respiration, requiring a grosser and more temperate Air.

But tho' from hence it appears, that the Air contributes to Respiration, in carrying off the

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Recrements of the Blood; yet it is scarce probable, that those Recrements should so soon kill an Animal, as to cause Birds inclos'd in our Receiver, to die in a few Minutes, for want of being carry'd off. And it would not be harder to account for such Effects, should we allow with *Paracelsus*, That Air contributed to the Generation of a Vital Spirit; since the Interruption of it's Generation, for so small a time could scarce be fatal.

Yet I shall add on this occasion, That I have been told, that *Cornelius Drebellus*, made a Boat for the Learned King *James*, which would swim under Water, in which, to make the Air included fit for Respiration, he was wont to open a Vessel which contain'd a Liquor, which added such a Vital Spirit to the Air, as purg'd it of the grosser Exhalations, and condens'd them. Wherefore I am the more favourably inclin'd to think that the Air may conduce to the Preservation of Vital Spirits; and that it contributes to the Preservation of Life, as Air to Flame; for having convey'd rectify'd Spirit of Wine into our Receiver, we found, that it would not continue long, no more than the Vital Flame of an Animal, if the Air was exhausted.

But not to insist upon these things, we shall add, That having dissected a Bitch, and taking out one of the Whelps, tho' we open'd his *Abdomen*, and *Thorax*, and divided the *Diaphragm*; yet having once began to breathe, his Heart continu'd to beat above six Hours; whereas three more, which were involv'd in the *Secundines*, in the mean time, were all dead; tho' they were neither wounded, nor had ever breath'd. How far
this

this may serve to illustrate the *Problem* propos'd by Dr. *Harvey*, viz. Why a *Fetus* may live longer before it hath breath'd; if involv'd in the *Scandines*, than if, when it hath once respired, Respiration be stopp'd, we leave others to judge.

Whether Fishes breathe or not, under Water, especially those that want *Lungs*, I cannot now determine; but that Air is necessary to the Preservation of their Lives, seems to be evinc'd, by observing, that if Fishes be inclos'd in a Bottle, which is close stopp'd from the Air; or if they be kept from the Air by the Freezing of Water, they presently die. And indeed, considering how many Particles of Air are interspers'd in the Pores of Water, it may not be altogether improbable, that part of it is separated, as it passes through their Gills, or some other way: And I am the rather inclin'd to believe it, because having put a large Eel into our Receiver, upon exhausting the Air, she turn'd up her Belly, and lay as dead, till the Receiver being unstopp'd, and the Fish taken out into the open Air, satisfy'd us of her Recovery, by very brisk and vivid Motions. But what is not a little to be admir'd, having put a Gray Snail into our Receiver, we perceiv'd not the least Alteration, when the Air was drawn out; but whence these *Phænomena* proceeded, we shall not now stay to determine.

Nor are we now at leisure to examine any further, whether the *Paradox* which some hold, be true, viz. That the Child respire in the Womb; only we shall say that it is not altogether Fabulous, That the *Fetus* hath sometimes been heard to cry in the Womb; and Chickens

have

have been observ'd to pip in the Egg-shell, before it was broke; which may be Arguments of an obscure Respiration; except it can be made to appear, That such Sounds may arise from *Flatulent* Vapours in the *Larynx*; and that they may, will not be a little favour'd, by observing what audible Sounds arise from the *Flatulent* Vapours of an *Edible* forc'd upon the Blade of a Knife, held in various Postures.

But to proceed, the Necessity of Breathing, tho' those that are not well are accusom'd to want it, may appear, from the small time, that such Men are able to stay under Water; but may further be illustrated by the following *Experiments*: For having convey'd a Humming-Bee, a Flea-Fly, and a Palmer-Worm, into our Receiver, upon the Exsuction of the Air in a Minute's Time, they all seem'd dead; but presently recover'd by the Re-ingress of Air; yet when the Air was again drawn out, they appear'd dead, which is a strong Argument to induce us to believe, that the Bodies of Animals are but so many Curiously-contriv'd Engins, except those of Men, whose Wheels are set on going, by the Influence of External Agents; for even those Flies, which presently die in our Receiver, will crawl about, even when their Heads are cut off. And it is not unworthy our Observation, That Insects which want *Lungs*, are no less sensibly affected upon the Exsuction of Air, than some that have them, which may be Grounds for a Suspicion, that the Particles of the Air enter in at their Pores, and that it keeps them alive by a Universal Perspiration.

But

But to put an End to this Digression: Tho' the Foremention'd Experiments have given me cause to suspect, that the Depuration of the Blood, is the chief Use of Respiration; yet since I believe it hath some other Uses, which are not yet explain'd, I shall conclude with that Saying of St. Austin's; *Mallem quidem coram quodam me quassivisti, habere Scientiam quam Ignorantiam: sed quia id nondum potui, magis elige Cautam Ignorantiam confiteri, quam falsam Scientiam profiteri.*

EXPERIMENT XLII.

The different Operations of Corrosives in, and without our Receiver.

HAVING fill'd the third part of a Long-neck'd Viol, with ten Sprigs of Coral, and as much Spirit of Winegar, as I wam about an Inch over them, we plac'd it in our Receiver; and tho' at the first there appear'd but very few Bubbles, yet upon a few Exsuctions of the Air, they rose so plentifully, as to make the *Menstruum* appear white, the whole continuing to boil and ferment, as in a Seething-pot, as much Froth standing upon the Liquor, as answer'd the Depth of it, in the Viol: Yet upon letting in the Air, the Froth presently disappear'd, and the Liquor became transparent again. And these Phenomena successively follow'd each other, no less than five times, as the Air was drawn out, or let in again; and the Ebullition in those Tryals, upon the drawing out of the Air, was so great sometimes, as to run over the Top of the Glasis; and that those numerous Bubbles might not be suspected to arise from the Spirit it self, we clear'd it of those, before the Coral was put in, but the same

Phen-

Phænomena, still succeeded: nor was there any considerable Difference, when the Tryal was made with Powder of *Coral*, except that the Liquor was obscur'd by several Parts of it carry'd up along with the Bubbles. But one thing in the foregoing *Experiments*, was remarkable, That tho' the Ebullition was so violent, yet the Viol immediately taken out of the Receiver, did not affect our Hands with the least sensible Heat.

EXPERIMENT XLIII.

HAVING clos'd in our Receiver a Viol of four Ounces fill'd with hot Water, which had been freed from Air by boiling, we pump'd out the Air, and observ'd, That upon the fourth Ex-fusion, it began to boil, as if it had been over a hot Fire, so that part of it ran over, and continu'd boiling in our Receiver. And what was more remarkable, was, that as often as the Air was let out of the Receiver into the Pump, the Ebullition was again renew'd, the Fiery and Agitated Parts of the Liquor, upon a Removal of the Air's Pressure, having more Liberty to expand themselves. And that the *Phænomenon* was promoted by the Removal of that Pressure, we may guess, because the Ebullition was only in the Top of the Liquor; and that it was renew'd upon a Removal of that Pressure. But especially, because Sallet-Oyl, whose Parts adhere, by Reason of their Clamminess, would not ferment; yet Oyl of *Turpentine*, or *Wine* would, whose Parts are not so tenacious; the former rising five times its Height, and near four Parts of the latter running over into the Receiver.

Of the spontaneous Ebullition of warm Liquors.

From

From all which Experiments it appears, that the Air may have a considerable Influence on a greater Number of *Phænomena* than Men usually think of, especially where the tumultuous Agitation of the Parts of a Body are concern'd; so that were a hot Body convey'd above the *Atmosphere*, the Effects of it would be different from what they are here below, and the Parts of it would have more Power to dissipate themselves.

Having thus far, My Dear Lord, given you a faithful Historical Account of the Productions of your Lordship's Commands, if they may invite you or your Friends at *Paris* to a further Prosecution of what Discoveries may be made by that Engin, I hope they may afford your Lordship as much Pleasure as they did me in endeavouring to express my self,

Your Lordship's

Most Obedient Servant, &c.

CHAP.

CH A P. XIV.

The Doctrin of the Spring and Weight of the Air defended against Franciscus Linus.

THIS Chapter containing the Honourable Author's Vindication of his own *Hypothesis*, concerning the Weight and Spring of the Air: It will not be requisite here to lay down, all the trivial Objections of *Franciscus Linus*; which are easily answer'd, by any one that hath but read and consider'd the Author's *Hypothesis*, and will at the first sight appear to be ill-grounded or invalid Arguments, or rather false Criticisms: But, it being more consistent with the design'd Epitomy, I shall only take notice of such, as may serve to illustrate the *Hypothesis* already laid down, and think it unnecessary to fill an Epitomy with, what our judicious Author did not repute as Arguments against his Doctrin: And especially, because the Learn'd World, by their General Consent have agreed upon what the Honourable Author hath taught: Wherefore I shall lay down only those Objections which may seem considerable, and annex their Solutions.

The first Argument alledg'd by *Franciscus Linus*, is, That, did the Suspension of the *Mercury* in the Cylinder, depend on the *Equilibrium* of the Weight of the *Atmosphere*; when a Cylinder is fill'd full and inverted, upon an Inversion of the Tube, and a Subtraction of the lower Finger, the *Mercury* would not subside, were

*The first
Argument
of Francis-
cus Linus
Answer'd.*

were its descent not promoted by the Dilation of the Air above the *Mercury*; for if it were, that Expansive Force would raise the Finger upon the upper Orifice of the Cylinder.

To which is answer'd, That the included Air may depress the *Mercury* by it's Expansion downwards, without raising the Finger; for the Weight of the whole Cylindrical Pillar of the *Atmosphere*, which presses upon the top of the Finger, being too strong to be overpower'd by the weak Expansion of the Air in the Pipe, it must consequently press downwards, where the Weight of the *Mercury* is ready to joyn with it to over-balance the Pressure of the Air, which before buoy'd it up: And that the Weight of the Cylinder of *Mercury* disposes it to spend its expansive Force downwards, appears from a Cylinder of Water suspended instead of *Mercury*; for the Weight of that being not able to resist the Pressure of the *Atmosphere* downwards, equally as the *Mercury*; the Air in the Top of the Cylinder does not press it down near so far: And tho' the Objector says, that if Water instead of Air be above the *Mercury*, it will not subside; the Reason of that is only, because the Water wants a Springiness to expand it self: And as for the Reason why the Pulp of the Finger seems to be drawn down into the Tube, that only happens, by Reason of the Weight of the Incumbent *Atmosphere*, the Rarifi'd Air within, not being able to make an equal Resistance to prevent the Finger from being press'd into the Pipe: And tho' the Objector further urges, that he cannot conceive how the Air can be so expand-
ed

ed without possessing a greater Space, we have sufficiently clear'd that, by comparing the Expansion of the Air's Spring to a piece of Wooll squeez'd together, which when it is no longer Compres'd, dilates it self by Virtue of its springy Parts.

The second Objection is, That if *Mercury* be suspended in a long Pipe, about 40 Inches long, when the Tube is inverted, and the Finger is taken from the lower Orifice, it falls down till it comes to its usual Station; and the Pulp of the Finger is equally depress'd into the Tube; which evinces, that the *Mercury* is suspended by a *Funiculus*, which draws down the Pulpy Part of the Finger. *A 2nd Objection.*

But, what Answer is to be given to this Objection, appears from what hath been said to the former; for the *Mercury* subsiding, till it came to an *Equilibrium* with the *Atmosphere*; the Air above it being very much Rarifi'd, and unable to buoy up against the Finger; the Depression of the Pulp of it must proceed from the Weight of the incumbent *Atmosphere*, tho' the swelling of the Pulp in the Pipe might perhaps partly proceed from an Expansion of the Humours within the Substance of it, the Weight of the *Atmosphere* being prevented from squeezing upon it by the Equivalent Weight of the *Mercury*. *Answer'd.*

Another Objection is, That if a Tube twenty Inches long, be immers'd in Quicksilver, and when it is full, the upper Orifice of it be stopp'd with ones Finger, as well as the lower, upon taking away the lower Finger, the Pulp of the upper will be drawn down, tho' the Weight of the *Atmosphere* is said to be able to buoy up a Cylinder. *A third Objection answer'd.*

linder much longer ; So that this is a plain Demonstration of the Suspension of the *Mercury* by a *Funiculus*, and that it is not buoy'd up by the Pressure of the *Atmosphere* according to the Elaterists.

But tho' this Objection may seem to represent some Difficulty, yet it will easily be answer'd, by thus explaining the *Phanomenon*, viz. Tho' when the Tube is stopp'd at both Ends, the Finger upon the Top of the Tube be equally press'd upon on both sides ; yet, upon a Removal of the Finger below, tho' the Pressure of the Air upon the Finger continu'd to be the same, yet the Pressure of the *Mercury* is by two Thirds less, against the Pulp of the Finger, its Gravity pressing upon the subjacent Air ; for notwithstanding the Air is able to buoy up a greater Quantity, yet that in part takes off the full Pressure of it, so as to make the Pressure upwards, disproportionable to that which tends downwards : And tho' the Objector urges, that the *Mercury* is equally suspended upon a Removal of the Finger, as before ; I answer, that the Finger presses it up much more strongly, to prevent any of it getting out ; whereas the Pressure of the Air only depends on the Weight of it, which cannot be intended or weaken'd, as that of the Finger may, which is capable of raising a much greater Weight.

Another
Objection
answer'd.

Another Objection alledg'd by the Author is, that were the *Mercury* buoy'd up by the Weight of the *Atmosphere*, it would be as easy to suck up *Mercury* in a Pipe as Water, nothing more being requisite but to draw away the Air.

But

But this may easily be taken off by considering, that the Dilatation of the Lungs depending upon an Ingress of Air upon the Motion of the *Diaphragm* and Intercoastal Muscles, and that Air being press'd in by the Gravity of the Air and it's Spring, it will follow, that that Gravity or Spring being more powerfully resisted by the Cylinder of *Mercury* than Water, the Lungs cannot so powerfully dilate; nor can the *Mercury* be rais'd with equal ease, because, that Air in the Lungs, together with the Weight of the *Mercury*, brings the External Force of the *Atmosphere* nearer to an *Equilibrium*. Besides, the External Air pressing upon the *Thorax*, and keeping them from dilating themselves, the Air contain'd in them, pressing against the Superficies of the *Mercury* in the Tube, is a further Cause, why it rises not so high; which Explanation is confirm'd by observing, that as the Lungs are more violently dilated, the *Mercury* rises higher in the Tube; and it will be further Probable, by considering, how much greater a Pressure may be made upon so large a Superficies as that of the *Thorax*, than can be resisted by the Rarifi'd Air in the Lungs. And as for the *Funiculus*, which our Author supposes to raise the *Mercury*, by contracting it self; it would not be a little strange, that it should raise such a Weight as a Cylinder of *Mercury*, without tearing off the thin Membranes of the Lungs to which such a *Funiculus* must, at one end be join'd.

To these Objections the Author adds an Inference, that if the Spring of the Air be of no Force, *in loco aperto*, no more can be effected by

it *in loco Clauso*; but the Place which the Object takes to be *in loco Clauso*, appearing to be only in a Room; It is answer'd, that whereas the former Objectoins appear to be invalid, the Inference must be so too; because there being a Communication betwixt the Air in a Room and the External, by some Holes or Crannies, or otherwise, the included Air will be able to do as much by its Spring, within as without.

CHAP. XV.

The Funicular Hypothesis Examined.

*Argument
in favour
of the Funi-
cular Hypo-
thesis exa-
min'd.*

THE *Hypothesis* laid down by our Adversary, and which is now to be examin'd, is, That what we ascribe to the Spring and Weight of the Air is done by a sort of *Funiculus*, consisting of a thin Substance powerfully expanded, which being betwix two Bodies, endeavours to contract it self, and to bring those Bodies together, *ne detur Vacuum*.

The first Argument alledg'd, is, That the Finger would not be so drawn down by the Descent of the *Mercury*, were there not a *Funiculus*; and that were there not a thin Substance there extended, there would be a *Vacuum*,

As to the first Part of the Argument, it hath already been answer'd in the foregoing Chapter. And tho' he alledg'd the Necessity of such a *Funiculus* from Nature's Abhorrency of a *Vacuum*; the first Argument he offers, being deduced from the Suction of the Pulp of the Finger upon the
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Descent of the *Mercury*, It is likewise already Answer'd by what hath gone before in Explaining that *Phænomenon*. But another Argument he alledges against a Vacuity is, the Diaphaneity of that Part of the Tube; for were there a *Vacuum*, he says it would be like a black Pillar, neither capable of affording any thing visible, nor of permitting visible Objects to appear through it: But the Invalidity of this Argument will appear from the Doctrin of the *Epiciens* and *Atomists*, who Teach, that Light is made up of such subtle Emanations, as are capable of penetrating Glafs it self, and tho' the Cavity of the Cylinder may seem full of Light; yet no doubt, but were the Parts of luciferous Matter condensed into a Lump, they would not fill half the Cavity; since the Smoak which fill'd up the Cavity of our Receiver, so as to make it appear Opaque, was but capable of filling a small part of it, when condens'd. Besides, should the *Torricellian* Experiment be made in the Dark, a *Vacuit* might argue, that the Matter, which upon an Access of Light was visible, was not in the Receiver before, but proceeded only from the Rays of Light darting through the Glafs: And tho' Light should not be caus'd by a Trajection of such luciferous Beams, but from an Impulse of luciferous Bodies; yet would it not thence follow, that the Tube was full; since from our seventeenth Experiment it appear'd, that when the Receiver was in a great measure exhausted, there remain'd a sufficient Quantity of Matter behind, to communicate a tremulous Motion to the External Air: And tho' it should be allow'd, that the Cavity of the Tube were fill'd with the Car-

tesian *Materia subtilis*; yet, since they allow that capable of passing in and out upon the Access of a grosser Body, it would not be any more to his Purpose, in maintaining his Funicular *Hypothesis* or opposing Ours, because such a Body as so easily passes in and out, will be as ready to give way to the Motion of a more gross Body, and consequently to the rising or subsiding of the *Mercury*.

Another Argument alledg'd in Favour of the Funicular *Hypothesis*, is, that when the *Mercury* is subsided to its wonted Station, it gravitates no farther. But it being already shewn, why it does not, *viz.* because it is counterbalanc'd by an equal Weight or Pressure made by the *Atmosphere*, what hath gone before hath been a sufficient Answer. And if it should be ask'd, why, when the Finger is press'd upon, by a Cylinder of the *Atmosphere*, and at the same time by a Cylinder of the *Mercury* on the other side, it feels no sensible Pain; it may be answer'd, that the Pressure being equal on each side, the Sense of Pressure is the less perceptible; which is confirm'd by what divers observe at a considerable depth under Water, *viz.* that they are not sensible of it.

And if it should be further ask'd, why upon the Descent of the *Mercury*, it, at the first, falls something below its wonted Station, and presently rises up again, it may be answer'd, that that proceeds from an *Impetus* acquir'd by its Descent, which at the first partly overpowers the Spring of the Air below it; but that *Impetus* being quash'd, the Spring and Weight of the Air presently weighs it up again to its usual Station;

tion; and having been put into a little more than ordinary Compression, raises it something higher; so that the *Impetus* upon a second Descent brings on a successive Elevation, till at the last the *Impetus* on each side gradually is lost, and discontinues that vibrating Motion; and this may not only be illustrated by the successive Vibrations of a Pair of Scales put in Motion by depressing one and elevating the other; but was farther confirmed by *Mercury* in a Glass Tube, made use of in our 36th Experiment, for having put a Quantity of *Mercury* into it, and by inclining of it permitted it to run into one Leg, I stopp'd the Orifice of the other with my Finger, upon which, the Tube being erected, the Air contained in the Syphon, which was stopp'd at the Top, depress'd the *Mercury* in that Tube; but as soon as it was unstopp'd, the vibrating Motions of the *Mercury* began and continu'd to rise and fall successively for some time.

CHAP. XVI.

A Continuation of Objections against the Funicular Hypothesis.

BESIDES the forementioned Objections, there are several others which perplex the Funicular Hypothesis: As first, How the superficial Parts of two solid Marbles, which adhere together, when exactly polished, can be drawn out into a *Funiculus*; a Difficulty which does not at

all perplex our Doctrin. Besides, were the Funicular *Hypothesis* allowed, it might be questioned, How it comes to pass, that Liquors whose Parts are not equally liable to be extended into such *Funiculus's* should exactly subside till *Equiponderant* to 29 $\frac{1}{2}$ Inches of *Mercury*, and no further; an Objection which our Doctrin admits not of, since not only from Wind-Guns, but our former Experiments, it appears too manifestly to doubt of the Air's Spring and Gravity.

Nor is the Author's strange Method of producing his *Funiculus* less exceptionable; for he says, When the *Mercury* touches the Top of the Tube, upon it's Descent, it leaves it's Superficies to stick to the Top of it, which is extended by the Weight of the *Mercury*, till it leaves another Superficies joyning to that; where it may be objected, That neither Sense perceives any such Thing, nor can it be made probable by Reason; it being impossible to conceive, How the Superficies of a Body can be so extended as to become a Body it self: And should it be allowed, that the *Funiculus* might be turned into so subtle a Body, it would be altogether inconceivable how it should be so firm and strong, as to suspend the Weight of a Cylinder of *Mercury*; and that it should have such an admirable Property as to extend without being made thinner, contrary to the Nature of all Ropes.

Besides, the Method he takes to illustrate his Generation of the *Funiculus*, by comparing it to the Flame of a Candle, does not enforce the Belief of it any more; for not to urge, That the

the Parts of a Candle, are by Agitation, and a powerful Motion amongst each other, kept at such a distance, as to leave several and a Multitude of Vacuities betwixt their Parts; if the Rarefaction of the *Mercury* in the *Funiculus* be like that, when it is rais'd in the Form of a Vapour, it would be too slight to suspend a Tube of *Mercury*. And it might be further demanded, How the *Funiculus* came by such Hooks, as to take hold of every Body contiguous to them, so firmly, as to be able to break strong Glasses, by drawing their sides inwards; and how Fluids should be so suspended, as to appear one entire Piece, contrary to what their Fluidity disposes them to do. Nor is it less strange, That our Objector should allow this subtle Body a Spring which he denies to be in Air; since Nature's Abhorrency of a *Vacuum* cannot be the Cause of it, in as much as a *Vacuum* would not ensue, according to his Doctrine, tho' it were not contracted.

Moreover, it would not be a little hard to conceive, were such a *Funiculus* allowed of, how the Surfaces of Marbles extended, could contract into Marbles again; and how in the Cylinder of *Mercury*, the *Funiculus* is so easily relaxed, upon an Admission of Air into it, since, it filling up all the Space above the *Mercury* before, it cannot easily be conceiv'd how it should be dispossest'd of that Space, without being thrust into another.

Again, I should be glad to know, if the Cavity of our Receiver, upon an Exsuction of Air, were fill'd with such stretched Strings, it would be possible for a Pendulum to move in it without break-

breaking them; but our Author's *Funiculus* being made up of Strings, endued with peculiar Qualities, we shall decline making any more Objections, since these Peculiarities may be sufficient to distinguish it from Truth.

CHAP. XVII.

The Aristotelian Rarefaction Examined.

The Aristotelian Notion of Rarefaction rejected.

BESIDES the former Objections which render the Funicular Doctrin unintelligible, there are yet others, upon the Account of the Doctrin of Rarefaction employed in the explicating of it.

For the Doctrin of Rarefaction made use of by our Author, supposing a Body not only to fill up a larger Space, when rarified, but likewise so to fill it, as not to leave the least Vacuities betwixt it's Parts; it will be very hard to conceive, How a Hundred Parts of Matter, which are circumscribed by so many Spaces of the same Extention with themselves, should be capable of filling up more Space adæquately than they are circumscribed by, without the Addition of other Matter; and it seems strange, That without the immediate Act of Omnipotence, Matter should be so extended as without any Addition to alter it's Dimensions.

And tho' our Author takes two Ways to explicate his Notion, either upon a Supposition of the Parts of Matter being indivisible or divisible *in infinitum*; yet, since he explicates it neither
of

of those ways so clearly, as to make it intelligible, I must confess, I cannot acquiesce in them; nor are the Difficulties at all made less by asserting, That Matter may be virtually so extended as to possess more Space than is circumscribed by it; since a virtual Extension is as unintelligible as Extension without the Term virtually joyn'd with it; for since he seems to allow the Parts of Matter to be indivisible, it rather prejudices the Doctrin of Rarefaction as taught by *Aristotle*, than explains it; since it is inconsistent to think, That a Body, whose Parts are circumscribed by a certain Space, should fill a larger Space, without being divided and removed out of the former.

Nor does it at all explain or render the *Aristotelian* Doctrin of Rarefaction, to say, That Matter may, by Omnipotence, be so ordered, as to possess adequately double the Space it did before; since in Natural Philosophy it is not disputed what *GOD* can do, but what he hath done.

But besides the Difficulties in our Author's Doctrin of Rarefaction, there are no less in the Condensation which his *Funiculus* supposes; for since he allows of no Vacuities in it, it is impossible the Parts of it should be brought nearer than to touch one another, without a Penetration of Dimensions, which is wholly disallow'd of, and by no means to be admitted in Nature; for were that allowed, two or three Thousand Bodies might be contained in a Space, which every one of them by it self would fill; which is altogether unintelligible.

CHAP. XVIII.

A Consideration concerning some Tryals of the Torrecellian and other Experiments' at the Tops and Feet of a Hill.

*The Height
of Mercury
suspended at
the Top of a
Hill.*

FOR a further Proof against Our Adversaries Doctrin, and for a Confirmation of ours, I shall add the following *Experiments*.

And First: The Famous *Pecquet* mentions an *Experiment*, made by *Monfieur Pascal*, at the Foot of a Mountain 3000 Foot high; where when he ascended, 150 Fathom, the *Mercury* in the Cylinder was not buoy'd up so high, as at the Bottom, by two Inches and a Quarter; and at the Top of the Hill, it wanted 3 Inches of that Station, which it was suspended at, at the Foot of the Hill; which is a strong Argument against our Adversary; the Difference plainly appearing to depend on the different Length of the *Atmospherical* Cylinder, which was abler to weigh up the *Mercury* at the Bottom, than the Top of the Hill.

And *Gassendus*, *Tom. 1. P. 211.* relates, that the like was observ'd 5 times on the Hills at *Auvergne*. And a very Noted Virtuoso, *Mr. J. Ball*, as well as that Ingenious Gentleman *Mr. Townley*, have observ'd the like in *England*. And it was by the last nam'd, likewise observ'd, that the *Mercury* included in the Top of the Cylinder, was not able to depress the *Mercury*, near so much at the Bottom, as at the Top of the Hill.

But

But to discover the weight of the Air, and it's Spring, without going up to the Top of such high Mountains, we made use of the following Weather Glass, suspending Water in the Pipe, instead of *Mercury*. The Instrument was a Glass with a broad Foot, and a narrow Neck (A B), and a slender Pipe of Glass (C D), which was open at both Ends; and so plac'd, that the lower End was not far from the Bottom (A B), and was so closely cemented at the Neck (A), as to prevent the Internal Air (I I) from communicating with External (K K), unless it were through the Pipe (C D). And having convey'd Water (H H) into the Glass (A B), which was pretty large, and having blown so much Air into the Bottle, as to raise the Water in the Tube above the Vessel, upon the Leads of *Westminster* Abby. When the Air was thought to be equally Cold and Condens'd within the Bottle, as without; we mark'd the Station of the Water (F), and letting it down by a String to the Ground, the Water subsided an Inch, where it's Station (E), being mark'd, and the Vessel drawn up again, the Water was rais'd to the Mark (F) again. Which *Experiment* being again try'd, had the like success. And afterwards the Top of the Tube being broke, we let it down within the Church, the Surface of the Water in the Pipe being at (G) an Inch above the Water in the Glass; where I observ'd, that the Air so depress'd it, when it came to the Bottom, as to force the Water out of the Pipe into the Glass, several Bubbles breaking through into the Capacity of the Glass, and this Glass being drawn up to the Top of the Church again, the Water was manifestly rais'd in the Tube again; from whence
it

See Fig. the
First, Plate
the Second,

it appears, that the *Atmosphere* gravitates more; *Ceteris paribus*, the nearer the Surface of the Earth; for the *Experiment* being repeated, we found that as the Height, at which it was try'd, vary'd; so the Elevation or Depression did.

Another Particular which may be a further Confirmation of our *Hypothesis*, is, That which is mention'd by Monsieur *Paschal*, viz. That a Foot-Ball being weakly blown, and carry'd to the Top of a Hill, swell'd more and more, as it was carry'd higher; and as gradually grew lank, when it was carry'd down the Hill again: From whence it appears, That as the *Atmosphere* is longer or shorter, it makes a greater Gravitation and Pressure upon the Bladder.

See Fig. the
Sec. Plate
the Second.

To this I shall add an *Experiment*, sent to Dr. Croon, by a Learned Professor of *Gresham College*, which is the following: Having Observ'd that in the Weather-Glass (A B), represented by the Second *Figure*, which was about two Foot long; the Water was suspended in the Pipe, about thirteen Inches above the Superficies of the External Water, at the Bottom of *Hallifax Hill*; but being carry'd to the Top of the Hill, it subsided an Inch and a Quarter, to the Point (D). The Internal Air (A C), which was taken in at the Bottom, dilating it self at the Top further by (C D). In which *Experiment*, the Descent being much more considerable than what it ought to be in such a small Ascent, by the bare Pressure of the *Atmosphere* diminish'd, the Reason appears to be, the Expansion of that Air included in the Top of the Weather-Glass; as well as the Shortning of the *Atmospherical Cylinder*.

CHAP. XIX.

Experiments concerning the Measure of the Force of the Spring of Air, compress'd and dilated.

TO make it evident, That the Spring of the Air is able to do much more, than we have attributed to it, upon the Account of its Spring and Weight, we try'd the following *Experiments*.

Having pour'd *Mercury* into a Glas-Tube, ^{The Air's} which consisted of a Long Leg, and a Short One, ^{Condensation made} which were so bent as to lye Parallel almost to each other; we pasted Papers upon each, which were divided by Marks into Inches, and each of those Inches into eight Parts; and upon pouring *Mercury* into the Longer Tube, we observ'd, That the Air contain'd in the Shorter, which was Hermetically seal'd at the Top, by twenty nine Inches of *Mercury*, was condens'd into half the Space it possess'd before; from whence it appears, that if it were able in so compress'd a State, by Virtue of it's Spring, to resist a Cylinder of *Mercury* of 29 Inches, besides the *Atmospherical* Cylinder incumbent upon that, it follows, that it's Compression in the open Air, being but half as much, it must have but half that weight from the *Atmosphere*, that lyes upon it, in that Compress'd State.

But

See Fig. 4.
Plate 2.

But to be more exact, we took a Tube represented by the Fourth *Figure*, pasting upon the Shorter Leg a Paper, divided into twelve Inches, and each of those into Quarters; and another upon the Longer Leg, which made up several Feet, which were likewise divided into Inches, and those subdivided again into Quarters. The Tube being thus Mark'd, the Lower End was plac'd in a Wooden Box, that the *Mercury* might run into it, if the Pipe chanc'd to break: And one being assign'd to pour in *Mercury* at the Top of the Tube, another was plac'd to observe, when the *Mercury* in the small Tube, rose up to each of the Divisions, abovemention'd; and to take notice likewise, how high it stood in the Long Tube, at the same time, where the several Observations were set down, and are contain'd in the following Table.

A

A Table of the Condensation of the Air.

A	B	C	D	E
48	12 00		29 $\frac{1}{16}$	29 $\frac{1}{16}$
46	11 $\frac{1}{2}$ 01 $\frac{1}{16}$		30 $\frac{1}{16}$	30 $\frac{1}{16}$
44	11 02 $\frac{1}{16}$		31 $\frac{1}{16}$	31 $\frac{1}{16}$
42	10 $\frac{1}{2}$ 04 $\frac{1}{16}$		33 $\frac{1}{16}$	33 $\frac{1}{16}$
40	10 06 $\frac{1}{16}$		35 $\frac{1}{16}$	35 $\frac{1}{16}$
38	9 $\frac{1}{2}$ 07 $\frac{1}{16}$		37 $\frac{1}{16}$	36 $\frac{1}{16}$
36	9 10 $\frac{1}{16}$		39 $\frac{1}{16}$	38 $\frac{1}{16}$
34	8 $\frac{1}{2}$ 12 $\frac{1}{16}$		41 $\frac{1}{16}$	41 $\frac{1}{16}$
32	8 15 $\frac{1}{16}$		44 $\frac{1}{16}$	43 $\frac{1}{16}$
30	7 $\frac{1}{2}$ 17 $\frac{1}{16}$		47 $\frac{1}{16}$	46 $\frac{1}{16}$
28	7 21 $\frac{1}{16}$		50 $\frac{1}{16}$	50 $\frac{1}{16}$
26	6 $\frac{1}{2}$ 25 $\frac{1}{16}$		54 $\frac{1}{16}$	53 $\frac{1}{16}$
24	6 29 $\frac{1}{16}$		58 $\frac{1}{16}$	58 $\frac{1}{16}$
22	5 $\frac{1}{2}$ 34 $\frac{1}{16}$		64 $\frac{1}{16}$	63 $\frac{1}{16}$
21	5 $\frac{1}{2}$ 37 $\frac{1}{16}$		67 $\frac{1}{16}$	66 $\frac{1}{16}$
20	5 41 $\frac{1}{16}$		70 $\frac{1}{16}$	70 $\frac{1}{16}$
19	4 $\frac{1}{2}$ 45 $\frac{1}{16}$		74 $\frac{1}{16}$	73 $\frac{1}{16}$
18	4 $\frac{1}{2}$ 48 $\frac{1}{16}$		77 $\frac{1}{16}$	77 $\frac{1}{16}$
17	4 $\frac{1}{2}$ 53 $\frac{1}{16}$		82 $\frac{1}{16}$	82 $\frac{1}{16}$
16	4 58 $\frac{1}{16}$		87 $\frac{1}{16}$	87 $\frac{1}{16}$
15	3 $\frac{1}{2}$ 63 $\frac{1}{16}$		93 $\frac{1}{16}$	93 $\frac{1}{16}$
14	3 $\frac{1}{2}$ 71 $\frac{1}{16}$		100 $\frac{1}{16}$	99 $\frac{1}{16}$
13	3 $\frac{1}{2}$ 78 $\frac{1}{16}$		107 $\frac{1}{16}$	107 $\frac{1}{16}$
12	3 88 $\frac{1}{16}$		117 $\frac{1}{16}$	116 $\frac{1}{16}$

Added to 29 $\frac{1}{16}$ makes

A, A, The Number of Equal Spaces in the Shorter Leg, which contain'd the same Parcel of Air differently Expanded.

B, The Height of the Mercury in the Long Tube, by whose weight the Air in the Short one, was compressed.

C, The Height of the Mercury, which counterpois'd the weight of the Incumbent Atmosphere.

D, The Aggregate of the Columns B and C, shewing what Pressure was sustain'd by the Included Air.

E, What that Pressure should be, allowing the Pressures, and Expansions, to be Reciprocal Portions.

But in Trying this Experiment, whoever pours in the Mercury, he must do it by degrees, and according to the Directions of the other, that takes notice of the Ascent of the Mercury below; for if it be pour'd in without Caution, it may rise up above

Cc

above the Marks plac'd on the Outfides, before due Observations can be made.

Having, by the weight of so vast a Cylinder of *Mercury*, compress'd the Air into a Quarter of the Space it possess'd before, we observ'd, tho' it could not be sensibly condens'd further by Cold, yet the Flame of a Candle brought near it, gave us reason to think, that a greater degree of Heat would have expanded it; but fearing the Cracking of the Tube, we durst not try it.

From the *Experiment* it appears, That as the Air is more or less compress'd, so it is able to counterpoise a Heavier or Lighter Cylinder of *Mercury*. And that the *Mercury* was born up by the Spring of that condens'd Air, appear'd by sucking up the Air out of the Tube, when the *Mercury* was 100 Inches high in the Pipe; for the Pressure of the incumbent Pillar of the *Atmosphere*, being by that means taken off, the *Mercury* was rais'd in the Long Tube, by the Expansion of the Air in the Short Leg: And not by any *Funiculus*, since the *Objector* confesses, that cannot raise more than a Cylinder of 30 Inches.

The Air's
Rarefaction
consider'd.

But, together with what hath been said, it may not a little illustrate our Doctrin of the Spring of the Air to observe, how much it's Spring is weaken'd, accordingly as it is differently Expanded, and Rarify'd.

A Table of the Air's Rarefaction.

A	B	C	D	E
1	00	00	29	29
2	10	00	19	19
3	20	00	14	14
4	30	00	9	9
5	40	00	7	7
6	50	00	5	5
7	60	00	4	4
8	70	00	4	4
9	80	00	3	3
10	90	00	3	3
11	00	00	3	2
12	10	00	2	2
13	20	00	2	2
14	30	00	2	2
15	40	00	2	1
16	50	00	1	1
17	60	00	1	1
18	70	00	1	1
19	80	00	1	1
20	90	00	1	1
21	00	00	1	1
22	10	00	1	0
23	20	00	1	0
24	30	00	1	0
25	40	00	1	0
26	50	00	1	0
27	60	00	1	0
28	70	00	1	0
29	80	00	1	0
30	90	00	1	0
31	00	00	1	0
32	10	00	1	0

Subtracted from 29, leaves

A, The Number of Equal Spaces at the Top of the Tube, which the same Parcel of Air was contain'd in.

B, The Height of the Mercury, which together with the Included Air, counterpois'd the Pressure of the Atmosphere.

C, The Pressure of the Atmosphere.

D, The Aggregate of B to C, representing the Pressure counterpois'd by the Included Air.

E, What that Pressure should be, according to the Hypothesis.

In which Experiment it is to be Noted, First, That we made use of a Glass-Tube, about 6 Foot long, sealed at one End.

Secondly, We had in Readiness a Glass-Pipe, about the Diameter of a Swan's Quill, which was mark'd with a Paper stuck upon it, divided into Inches, and half Quarters; which being immers'd in the other Cylinder of Mercury, and open at both Ends, that the Mercury might rise in it, it help'd to fill the other up. And about

an Inch of it's standing above the *Mercury*, the Orifice was seal'd up; so that an Inch of Air was contain'd in the Tube, which, by lifting up the Tube, was gradually expanded to several Inches: It being noted, in the mean time, how much the *Mercury* in the small Tube, was, by the Expanded Air, in several Stations, permitted to rise above the Surface of the *Mercury* in the other Tube: By which Method, the former Observations being made, we inverted the Large Tube, and found by trying the *Torrecellian Experiment*, That that Day the Air sustain'd the *Mercury* at 29½ Inches; where it was observ'd, That in making the foregoing Observations, the Difference betwixt the Account which answers our *Hypothesis* and the other, probably proceeded from a new Access of Air, to that included Inch; and indeed, by immersing the Tube, when the Observations were made, we found, that it had gain'd about half an Eighth; which we judg'd might arise from some Bubbles lodg'd in the Pores of the *Mercury*. From which *Experiment* it appear'd, that the Inch of Air expanded to double it's Dimensions; was able with a Cylinder of *Mercury* about 15 Inches, to counterpoise the Pressure of the *Atmosphere*; which would raise the *Mercury* eight and twenty Inches, when the Spring of that Air was lost, by a further Expansion: So that the *Atmosphere* here below, must consequently be as much compress'd, as if twenty eight Inches of *Mercury* gravitated upon it.

CHAP.

CHAP. XX.

*Objections against Particular Phænomena
answered.*

WHAT our Author says in the Vindication of *Particular Experiments*, being only a Repetition of what he had said before against the *Objector's Funicular Hypothesis*, there is no need now to make a Repetition; since the *Funicular Hypothesis*, being already confuted, it consequently follows, that the Explications are Er-
The reason why Air condens'd by Cold, does not raise Mercury equally, as when condens'd by Pressure.

I shall therefore only take Notice of what hath not yet been deliver'd, or not so fully explain'd.

And First, The Reason why the Air condens'd in Winter, by Cold, does not buoy up the *Mercury* equally, as when the Air is condens'd in a Vessel, is because that condens'd Air adds no greater a Weight to it; but as a pound of Feathers, it is as heavy when compris'd, as before that Compressure; but when expanded Air is condens'd in a Vessel, it acts more Powerfully by Virtue of it's Spring.

Mr. *Boyl* hath taken a great deal of Pains in his *Explications*, to shew several Absurdities in the *Objections*; but those being neither Useful, nor Instructive, especially considering the *Objector's Hypothesis* is wholly laid aside, and our Author's Receiv'd, it will be needless to take notice of what will be of no Use in Explicating the *Phænomena* before deliver'd.

CHAP. XXI

An Explication of Rarefaction.

IT being objected by the Author of a Book, *De Corporum Inseparabilitate*, that the Spring of the Air cannot be made out, whether we allow a *Macrum*, or a *Plenum*. Waving the Forms which he lays his Objections down in, and a particular Answer to his Ways of Arguing, I shall take the following Method, to explain the Air's Spring. For supposing the Particles of the Air to consist of Matter, extended into thin *Lamina*, and those wound and folded up, like the Spring of a Watch; and that these Parts of Matter so wound up, are in a Continual Circular Motion, it will follow, that the *Lamina* in this Motion will endeavour to extend themselves, and to recede from the *Axis* or Center of their Motion, till hinder'd by the Opposition of each other, or some adjacent Bodies: and this Expansive Endeavour will be proportionably increas'd, as the Circular Motion of those Particles is quicken'd. And these Springy Corpuscles thus shap'd, and thus Mechanically mov'd, are sufficient to account for all that we ascribe to the Spring of the Air. For supposing the Diameter of those Parts of Matter next the Surface of the Earth, compress'd by the whole Weight of the Incumbent *Atmosphere*, to be ~~about~~ of an Inch, and to be represented by the Third Figure *A B C D*; it will Naturally follow, that Part of the Incumbent Weight of the *Atmosphere*, being taken off, they will expand them-

See Plate
the Second

themselves so as to be ~~represented~~ of an Inch in Diameter, as represented by E F G H. so that these Zones whirling round, will take up a space 1000 times bigger than before. And as from hence the Rarefaction of the Air is naturally accounted for; so the swelling of a Carp's Bladder, upon taking off the Pressure of the *Atmosphere*, is explain'd by the same Reason. And as the spontaneous Rarefaction of the Air is hence naturally explain'd, so it's Forced Rarefaction by Heat, is; for if the Particles of Heat penetrating the Interstices of these Aery Particles be in a violent rapid Motion, by increasing the Motion of the former Particles, they increase the Motion of the latter, and consequently strengthen their expansive Virtue; And if these Rarifi'd Parts of Matter, by expanding themselves, leave larger Interstices betwixt their *Lamina*, they must consequently be more pervious to the Rays of Light. So that granting this innate Motion in the Parts of Matter, and such a Configuration as I have mention'd, it naturally follows, that all the *Phænomena* belonging to Rarefaction and Condensation, may easily be explain'd by it.

Nor will it be impossible to explain the Rarefaction and Condensation, admitting of a *Ple-num*, if we suppose with *Cartesius*, That the Air consists of Parts which are long, slender and flexible; for supposing with him, that these are whirl'd round by the Rapid Motion of the *Globuli Cælestes*, those that lie next the Surface of the Earth, must needs be compress'd and hinder'd from that expansive Motion, more than those that have less Weight upon them; and consequently, when that Compression is taken

Rarefaction
according to
the Doctrin
of the Ple-
nists.

off, the expansive Force being encreas'd by it, they will consequently be expanded more Powerfully; and by whirling round, acquire longer *Vortices*: And for the like Reason the Air contain'd in the Carp's Bladder, will extend it self when the Pressure of the External *Atmosphere* is taken off; and consequently, when the External Pressure is again admitted, those springy Parts being again compress'd are less able to maintain their new *Vortices*, but being wound up together again become more condens'd, that Pressure resisting the Force of their Spring. And as for the Reason why Water flows into the Receiver again in the *Magdeburg* Experiment, so impetuously; it hence evidently appears to proceed, from the Weakness of the Spring of the included Air, not being able to resist the more violent Pressure of the External; and for the same Reason likewise, the Carp's Bladder upon a reingress of that Air, is presently compress'd into its former Inconspicuousness.

*Elasticity
explain'd by
the Carte-
sian Hypo-
thesis.*

Nor will it be a less Piece of difficulty to explain the Aptness of Explosion in Gunpowder, by the *Cartesian Hypothesis*; for the Parts of that Combustible Matter of which it is made being shattered and broke into Pieces, consequently become more apt to be whirl'd about by the *Materia Subtilis*, and justling against each other, take up 1000 times as much space as before; and these Parts being thus agitated whatever Gunpowder they fall upon, they presently shatter its Parts so as to put it in a Capacity to be agitated by the *Materia Subtilis*: and consequently, the *Globuli secundi Elementi*, being expell'd out of the Place which contain'd the Gunpowder, and

and the Parts of it being impetuously mov'd in that, they not only burst the Vessel they are contain'd in, but drive every thing out of its Place which stands in their way, and is not able to resist them.

CHAP. XXII.

An Explication of the Rota Aristotelica.

NOT to mention all those Absurdities which Mr. Boyle hath shew'd in the Author's *See Plate the second Fig. 5.* Explanation of the *Rota Aristotelica*, I shall pass on to lay down what Explanation Mr. Boyle himself gives of it; for Mr. Boyle conceiving no such Difficulties in it, as our Author would represent, says, that it is so far from containing any Obscurities in it, that it is plain and easie. For if the Wheel A B C D. be mov'd in a direct Motion from A I C. to K L M. each of the Points A E I G G. will either on a Plain, or in the *Medium* it passes through, form so many parallel Lines to I L. But if instead of that direct Progressive Motion, it have a Circulation, each Point in one Revolution, whilst mov'd from G to L. will form a Cyclorid. Besides, each Point of the Circle acquires various Degrees of Celerity in its Progression by this complex Motion, according to its various Position to a Point, which is always to be found in some part of the Line, drawn from the Center of the circular Motion Perpendicular to the Progressive; for as the Circumference to the *Radius*, so is the Line of the Progressive

gressive Motion to the distance of the Point from the Center; because the Line of Progression is equal to the Circle, describ'd on that distance as *Radiu*; and therefore, each Point of the smaller Circle, when it touches the Perpendicular, will in respect of its Progressive Motion stand still: This Point therefore, will be the Center of the complex Motion.

Our Author's Explanation of the Rota Aristotelica.

But since it may sufficiently explain the *Rota Aristotelica*, if we only consider those Points which pass across the Perpendicular, we shall suppose in our Example that A is the Center or immoveable Point; and then the Circumference A B C D will be equal to I L or A K by our *Hypothesis*. And since the Point I hath only one motion, viz. that of Lation, the Point C which hath two Motions, must have double the Velocity of I, and the Point F having the same Degree of Lation with I, and put half the Distance of G from the Center I, it must have one Degree of Motion and a half.

And further, the Point E having the same Progressive Motion with I, and being mov'd backwards with half the Velocity, loses half the Progressive Motion forwards. And the Point A being by its Progression mov'd forwards, with an equal Velocity with I, and by its Rotation (the Circle A B C D being equal to the Line I L) being carried back with equal Celerity, must necessarily stand still as to the Progressive Motion.

Now from hence it appearing, that the Point A, (being at Rest, by reason of its two opposite Motions) only touch a Point of the Line A K, without being in the least mov'd upon it, and

and that the Point E, (moving forwards as fast again as it is carri'd backwards by its Rotation, and consequently mov'd half as fast as the Point I) not only touches the Line E K, but is mov'd upon it with a progressive Motion, half as quick as that of I, it will consequently follow, that each Point in E must make a small Line, which is a Part of the whole E C; so that the Contact of the former, and the Contact and the Progression of the latter, being perform'd by an infinite Succession of Points, in an infinite Succession of Instants, the Difficulties represented by our Author's Explaining it, are taken off, all that he says coming to no more, than that *in such a determinate Moment or minutes Space of time, such a determinate minutes Corpuscle, will successively pass over such a determinate Space or Length.*

C H A P. XXIII.

An Abstract of what is further contain'd relating to the Weight and Spring of the Air in the Examen of Mr. Hobbs his Dialogus Physicus.

IN this Chapter I shall not take notice of what Absurdities the Author hath shew'd Mr. Hobbs guilty of, but shall only extract what may tend to a further Illustration of the Doctrine of the Air's Weight and Spring.

And first, from what hath been before deliver'd concerning the Weight and Spring of the Air, it appears, that the Reason why the Water

ter

ter in a watering Pot, is prevented from descending through the Holes of the Bottom, by stopping the upper Orifice, is no other than the Pressure of the *Atmosphere*; which making a stronger Resistance than a Cylinder of Water of such a Length is able to resist, it must consequently be suspended in the watering Pot: and that this is the true Reason, appears from what hath been deliver'd in the nineteenth Experiment; where it was made evident, that if the Pressure of the Air was weaken'd by extracting the Air out of the Receiver, as soon as the Water in the Tube was able to out-balance the Spring of the included Air, it began to subside.

CHAP XXIV.

The VVeight and Spring of the Air asserted.

THE Author having prov'd the Weight of the Air, by weighing it in an exhausted Receiver in a Lamb's Bladder, and a Glass Bubble, and likewise in an *Aelipile*: And the Air's gravity being further confirm'd, by weighing the Receiver before and after it had been exhausted in the *Magdeburg* Experiments: All that Mr. *Hobbs* objects, relating to the Bladder weigh'd in the Receiver, only intimates, that the Air being blown into the Bladder, the Weight proceeds from Atoms which swim in that Air, or the *Halitus* which pass into the Cavity of the Bladder along with the Air: But since this denies

nies not the Weight of the Air, but rather questions the Cause; we think it sufficient to account for what we aim'd at, to prove, that Air does gravitate, tho' the Cause of Gravitation be not known.

As to the Spring of the Air, waving what trivial Objections Mr. *Hobbs* makes, I shall add the following Experiments to evince it. *The Spring of the Air proved.*

The first, is, That if a Cylinder of *Mercury* be suspended at the usual Height, in the *Torresellian* Experiment, by stopping the upper Orifice of the Tube, and lifting the lower End above the *Basis* it rested on before; we may observe, that the Finger can discern no Gravitation of the *Mercury* in the Tube; but if it be inverted, and the External Air let in, the *Mercury* which before did not gravitate upon the Finger, will be so depress'd by the Spring of that Air, as to cause it to weigh considerably upon it; and if the lower Orifice be unstopp'd in the restagnant *Mercury*, the included Air will depress that in the Tube, below its former Stations: And if the Experiment be made in a Tube not so long, and both Ends be stopp'd with ones Finger, upon the removing of the uppermost, the lower will perceive the Weight of the Incumbent Pillar of the *Atmosphere*, which before depress'd the Pulp of the Finger into the Cylindrical Cavity of the Tube; so that this Experiment proves both the Spring and Gravity of the Air.

The other Experiment is the Fourth in the *Epistle*, where it was evident, that a Bladder suspended in the Receiver, subsided or swell'd as the Air was let in, or drawn out: And tho' Mr. *Hobbs* teaches, that the swelling of the Bladder

Bladder is effected by the Air, *per vim incassum*, which getting into the Bladder, presses against the Internal Superficies of it in their circular Motions; yet, since from several Experiments it appears, that Bladders are impervious to Air, to deny that the Ingress of it, is a sufficient Answer to his Explanation: But further, were the Bladder so pervious to Air, it might as readily get out of the Bladder, as in, without breaking it.

And whereas Mr. *Hobbs* endeavours to explicate all the *Phænomena* afforded by our Engin and Wind-Guns, by the Motion of the Aery Parts, which Motion they acquire by the Force of the Engin; yet, that the Air hath parallel Effects where it acquires no such Motion, appears from the Experiments formerly mention'd made in the open Air, at the Top and Bottom of Hills; the *Mercury* being not near suspended so high at the Top, as at the Bottom of those Hills. And tho' he endeavours to Explain the difference, by supposing the Motion of the Air brisker at the Bottom than the Top of the Hill; yet, since it can only keep the *Mercury* from subsiding, by virtue of its Pressure, that Pressure must either proceed from its Spring or Weight; and since it is highly improbable, that the Pressure of so few Parts of the Air, as are contiguous to the *Mercury*, should be able to keep it from subsiding, it must do it by virtue of the whole *Atmosphere* which is equiponderant to it.

But to evince the Spring and Pressure of the Air further, I shall add, that a *Thermoscope* being carri'd to the Top of a Hill, the Air contain'd in it not finding so strong a Pressure from the

the Water, which there receives a less Impression from the *Atmosphere*, visibly expands it self by virtue of its Spring.

C H A P. XXV.

Mr. Hobbs's Principal Explications of the Phenomena of the Engin Examind

BEfore Mr. *Hobbs*, sets about an Explication of the *Phenomena* exhibited by our Engin, he lays down an *Hypothesis*, which he endeavours to explain them by; supposing that a great many earthy Particles are interspers'd in the Air, which have a congenite circular Motion of their own; and that there is a greater Quantity. of them nearer, than further from the Earth: But besides that it may be question'd, how such Particles can move in so exact an Order, without knocking against, and disturbing each others Motion: It is as unintelligible how Matter should have its Motion congenite: But to leave Mr. *Hobbs* to dispute these things with other Adversaries, I shall proceed to his Explications.

And first, to prove that there is no *Vacuum* The exhausted Receiver void of Air. in our Receiver, he says, that the Air being remov'd by the Pressure of the Sucker outward, it gets into the Receiver again betwixt the Convex and Concave Surfaces of the Sucker and the Cylinder, which if true, it would follow, that there was a *Vacuum* for some time, viz. till the Air had time to get into the Receiver

ceiver again. But that the Air is in a great Measure drawn out, and that the Receiver is, in respect of Air, empty, not only appears by those Bubbles of Water which pass through the Water, when the Receiver is encompass'd with it; but it further appears, by weighing the Receiver when exhausted, which is considerably lighter than before. As also, by observing, that if the Receiver be ill shap'd, so as not to be able to resist the Pressure of the outward Air, it breaks inward upon the Action of the Pump. But a further Argument is, that the Receiver being exhausted, and the Cocks turn'd when the Receiver is encompass'd with Water, several Gallons will be impell'd into it, which could not be without a Penetration of Dimensions, except the Receiver was empty. And even in the Common Experiment its evident, that the Air, upon turning of the Stop-Cock, rushes in with a considerable Noise.

But if Mr. *Hobbs* should say, that the Purer Air only flows into the Receiver; I shall demand, how it is possible for that to flow in, when the Receiver is exhausted in Water; where we might expect, that it should as well raise Bubbles in its Passage through it, as that such Bubbles rise in the Water in the exhausted Receiver.

And tho' Mr. *Hobbs* affirms, That this Air getting into the Receiver moves up and down violently I know not how; to prove that it does not I shall intimate, That were it so, the Smoak as well as the Bladder contain'd in the Receiver in the forementioned Experiments, would be disturb'd by that Motion; since upon the

the Admission of the Air into the Receiver, it appears, That it puts them both into a very violent Agitation.

And, That in the *Torrecellian* Experiment, the Tube above the *Mercury* is void of Air, may be evinc'd, by reciprocally inverting the Tube; for by that Means, the *Mercury* will move backwards with a much greater degree of Swiftneſs and Force, than if Air be let into that Part of the Cylinder which is not filled with *Mercury*.

And indeed, were it not allowed, That the Air is drawn out of the Receiver, for any thing that Mr. *Hobbs* hath offer'd, the Reason of the Aſcent or Deſcent of the *Mercury*, as the external Air is let in or drawn out, would be difficultly underſtood, if not altogether unexplain'd, without admitting the Weight and Spring of the Air.

The next *Phænomenon* Mr. *Hobbs* offers to explain is, why the Sucker riſes up when the Receiver is exhausted, tho' a hundred Pound Weight be ſuſpended at it; the Reason of which he attributes to the ſwift and violent Repercution of the Air, which was thruſt out, which finding not room enough in the World, muſt conſequently preſs the Sucker before it into the Space which contain'd it before; but if the Air be ſo ſwiftly repelled, I cannot underſtand, why it ſhould not reſiſt the Egrefs of Air, or raiſe the Sucker when a greater Weight is hung at it. But further, that the return of this Air does not depend on the ſwift Repercution of the external Air is hence manifeſt; ſince if the Sucker be held down till the Air about it ſeems

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to be settled, and as calm as before; it will nevertheless rise when the superfluous Weight is taken away. And as for an Internal *Conatus* of the Included Air, were such allow'd, as Mr. *Hobbs* contends for, it would rather hinder than promote the Rising of the Sucker; for were that Included Air forc'd out so violently, as he supposes, and were it strong enough to cause a violent Repercussion in the Air, the Internal Force counterpoizing the External, the Rising of the Sucker would not thereby in the least be promoted: But since from our *Experiments* it appears, That the Receiver is, for the greatest Part, void of Air, and that such an *Impetus* would be of no Force, in causing the *Phænomenon* he endeavours to explain by it, it is more Natural to believe, that the External Pressure of the *Atmosphere* rais'd it.

CHAP. XXVI.

*Several scatter'd Explications, and Passages
in his Dialogue, consider'd.*

WHEREAS we have in the XXXVth *Experiment*, mention'd an *Experiment*, wherein the Water Rose up into a long slender Tube, which was plac'd in a Perpendicular Line; the Water in the Tube, being above the Surface of the Water, without the Tube; Mr. *Hobbs* endeavours to explain this, by the Impulse of the Particles of Matter, swiftly agitated in the Air; but since the same Agitation
of

of Parts within the Tube, might also depress that to an equal Surface, with the External, the Account he gives of it, is the less satisfactory.

The Reason which he assigns for the Difficulty in drawing up the Stopple, when the Receiver is exhausted, is, a Violent *Conatus*, proceeding from the Motion of the Particles within; but were the *Impetus* so great, as to cause so great a Repercussion, as Mr. *Hobbs* before suppos'd able to repel the Sucker, it should rather raise the Stopple; and if that Motion contributed to the fastning of it, it would continue upon a Re-admission of the Air; since the Air in the Cavity runs about, and is in Motion for a good while: Nor could the Plenitude he supposes, cause the *Phenomenon*, because he supposes the World to be equally, and at all times full. But that the close Connexion of the Stopple to the Socket, depended on the Pressure of the External Air, appear'd by closing the Hole in the Cover with Cement, instead of that Stopple; for when the Air was drawn out of the Receiver, the External Air would press so violently upon it, as to make the upper Superficies Concave, and sometimes to force it down into the Receiver with a Noise, and great Violence.

He further assigns the Boiling of Water in our Receiver, to the Motion of the Air included; but since I have made it appear, That there is no such Motion, our Explanation is the more probable; since the Parts of the Liquor being agitated by Heat, will be apt to expand more powerfully upon a Removal of that Pressure.

And tho' he says the Parts of the Water could not be mov'd, except à *Movente contiguo*, A Con-

signous Body in Motion; yet since he allows, that the Motion of his Earthy Parts, which swim in the Air is innate, and consequently depends not on any Contiguous Body, I shall leave that to answer what he here delivers; and shall only intimate, That the Parts of the Water being agitated, when put into the Receiver, is enough to account for the *Phænomenon*, when the Pressure of the Air is taken off.

Why Animals die in the Exhausted Receiver.

The sudden Death of Animals, which I ascribe doubtingly, tho' not without Probability, to the Exsuction of the Air in the Receiver, he attributes to the Circular Motion of the included Air, and it's Tenacity; but since I have already made it appear, that there is no such Motion, that is a Sufficient Answer. And as for the Air, being thicker in the Exhausted Receiver, than before, the contrary appears in the *Magdeburg Experiment*; where the Exhausted Receiver weigh'd much less than before; but from the Breaking of Bubbles outwards it further appears, that it is not a thicker, but a lighter and more yielding Body: And tho' Mr. *Hobbs* from his supposition of the Air's Thickness, endeavours to Account for the sudden Extinction of Flame in our Receiver; yet thinking it a Matter of Difficulty to explain, the true Cause of the Extinction of Flame, it may suffice, that I have made it appear, that the Air is not thick as he supposes.

CHAP. XXVII.

Several other Passages in Mr. Hobbs's Dialogue, examined.

IN this Chapter Mr. Hobbs objects against what our Author delivers, concerning the Cause of the Cohesion of two Marbles; but all that is contain'd in what he here offers, being obviated by what hath been deliver'd under the Title of *Fluidity*, and *Firmness*; For a further Confirmation of the Doctrin there deliver'd, I shall add the following *Experiments*: And,

First, If an *Alipile* freed from Air, be, whilst ^{The Pressure of the Air upon Bodies contain'd in it, prov'd.} hot, stopp'd with Wax, upon a Perforation of that Wax, the Air will be press'd in to the Cool *Alipile*, whether the Orifice be held down, or ^{it, prov'd.} Horizontally; which shews, that the Air on each side may press upon the Lower Superficies of the Marble, as well as the Subjacent Pillar of Air, and that the Air is not impell'd against it only in a *Pyramidal Figure*, as he would urge, viz. because Lines drawn from the Circumference and Borders of the Stones, to the Center of the Earth, must form Pyramids.

To which it might be added, That Part of the Air being drawn out of a large Glass, and a Book clapp'd upon the Orifice, the Pressure of the Subjacent *Atmosphere*, kept it suspended there.

And the Author of the *Magdeburg Experiment* says, That two Plates of Copper, whose Diameter was about half an Ell, stuck so close to each other, that six Men could not pull them asunder.

* See Fig. 6.
Plate second

* And it appears from an *Experiment* made in a Glass Viol, anon to be describ'd, that if the Tube be so immers'd, that it's Lower Orifice just touch the Water, the oblique Pressure of the *Atmosphere*, will raise the Water in the Tube, a considerable Height, as the Air is suck'd out of the Tube.

Mr. *Hobbs* objects against the Author's Explanations of the Rising of Water in Glass Fountains; and says, That it cannot be accounted for by the Expansion of the Air, since the Parts of the Air expanded, take up no more room after they are expanded, than before; but since he means so as adequately to fill more Space; and we only mean such an Expansion, as is before explain'd, by instancing compress'd Wool; it appears, that in our Sense it will take up more Space, so as to keep the gross Parts of Water from getting betwixt them.

There are other Objections mention'd in this Chapter, as well as some other Particulars, relating to the *Royal Society*; but since the Author finds no weight in them against any thing he hath taught; I shall only further take Notice of what Mr. *Hobbs* and *Gassendus* teach, concerning the Rise of Water in *Syphons*; viz. That it is performed by Suction. But not now to mention what hath elsewhere been deliver'd to prove the contrary, I shall only add the following *Experiment*: Having taken a Glass Vessel, which was large enough to contain about a Pound of Water, I cans'd a Glass Pipe to be fix'd in the Neck of it; so that the Air within was kept from having any Intercourse with that without, the Lower End reaching almost to the Bottom of the Vessel: The Pipe being thus fix'd, we convey'd Water into the Bottle,

tle, till it rose something above the Bottom of the Pipe, and then having inclin'd the Bottle to give a due Intercourse betwixt the Internal and External Air, I suck'd the Air out of the Tube, till the Water rose into my Mouth, and till the Spring of the Included Air, was able no longer to lift up the Water; which would not have done, been were the Common Notion of Suction allow'd, *viz.* That it is effected by the Pressure of the Air, thrust away by the dilated Chest of him that sucks, and thereby drawing the Water into the Pipe at which he sucks.

But besides the Preceding use made of this Experiment, I pour'd out the Water, till the lower End of the Pipe was but just immers'd in it; and upon Suction, it rose almost to the Top of the Pipe; but the Spring of the Air being too much weaken'd to raise it higher, several Bubbles of Air broke through the Water; but as soon as I left off sucking, the Pressure of the External Air so compress'd the Rarify'd Air within, as to bring it to it's wonted Station, several Particles breaking into the Bottle through the Water, till that Internal Air was equally press'd with the External.

CHAP. XXVIII.

What Mr. Hobbs teaches concerning Fluidity and Firmness, examin'd.

Motion the
Chief Qual-
ification in
order to
Fluidity.

THE First Particular examin'd in this Chapter, is a Mistake of Mr. *Hobbs*, concerning the Author's Opinion of *Fluidity*; the Objector making the Author's Notion of *Fluidity* to consist in the Size of the Parts of Liquid Bodies; whereas our Author assigns Motion, as the Chief and Principal Qualification; since a *Coagulation* of pure Spirits of Urine and Wine, may by bare Digestion, be turn'd into a Permanent Liquor; and Quick-silver, tho' fluid, may be turn'd into a Permanent Powder, by stopping the Motion of it's Parts. And tho' Mr. *Hobbs* further asserts, That Fluid Bodies consist of Parts Divisible into Fluids, as Quantity into Quantity; yet, since I have made it appear, That Fluidity depends on the Shape, Size, Texture, and Motion; and Firmness, on a Rest amongst the Parts of Solids; and likewise, that Fluids are not divisible into Fluid Parts, as Quantity into Quantity, it is needless to repeat what is there deliver'd.

As for the Explication of Fluidity and Firmness, which Mr. *Hobbs* Substitutes, it teaches, That the Parts of Fluids may move whilst the whole is in Motion; and that Solids may have their Parts in Motion, tho' the whole lyes still: As also he says, That the Parts of a Fluid may be render'd less fluid, by being compress'd; but since he hath
asserted

asserted these things, and not prov'd them; and since the *Hypothesis* he goes upon, is sufficiently invalidated before, the Author thinks these require no Particular Answer: And tho' he further makes an Objection against the Size of the Parts of Matter contributing to Fluidity and Firmness; yet since our Author makes Motion or Rest the Chief and Principal Requisites, what hath been deliver'd in the History of Fluidity and Firmness, may suffice for an Answer: For that there is Motion in the Parts of Fluids, appears, if a Lump of Salt be put into Water, the Parts of which will be presently dissolv'd, and carry'd up to the Top of the Liquor, which could not be without Motion; and that Rest contributes to Solidity, is evident, since Water froze, becomes Ice; and on the contrary, that, as well as Metals, by having their Parts put into a violent Motion by Heat, become Fluid.

CHAP. XXIX.

An Explanation of the Engin made Use of in the following Experiments.

THE Structure of our Engin being such, as not to admit of an Alphabetical Explanation, so as to make it intelligible, to those that are unacquainted with Mechanical Structures, and it being easily enough understood by those, especially that are acquainted by our First Engin, we thought

See Plate the Third and Fourth.

thought it sufficient in our *Plate*, to represent the *Engin* just ready to be set on Work; and in the Fourth the Parts, which it is made up of. Only there are two things, which may deserve to be explain'd: First the Sucker being always cover'd with Water; and the Perforation (p q), which goes through it in a Perpendicular Line, and together with the Stick (r s), supplies the Place of a Valve, being to be stopp'd at the Bottom of the Cylinder (n o), when fill'd with Water; it was necessary the Stick (r p) should be of a considerable Length. Secondly, The Pipe (A B) lies in a Gutter, made purposely in the Board (c d e f), which Board is laid over with Cement, and a piece of Iron laid upon that, to keep it from warping: In which Iron-plate is fix'd a Lip, which rises up about the End of the Pipe (B), which is bent up, to prevent the Water which comes from the Receiver from being Spilt; and notwithstanding the Stop-cock (G H I K), might be inserted into the Cylinder (L M N O), at (I) with Soder; yet it is much more convenient to have the Branch (I) made like a Screw; so that being screwed into the Barrel, it may more easily be mended, when any thing is amiss; Whether it be that the Air gets in betwixt the Plate and the Wood, or the Cement be drawn into the Pipe, where the inverted End is united to the Receiver; and lest the inward Orifice of the Pipe should be stopp'd with any thing, contain'd in the Receiver drawn to it, there is fix'd at some Distance from it a Tin Plate, so contriv'd as to give free Passage to the Air.

The

The Wooden Part represented in the Plate, and which contains the Cylinder, is always so full of Water as able to overtop the Cylinder, and to make the Sucker soft and plump, by which means it is more exactly fitted to the Cylindrical Cavity.

And as for the Iron Plate abovemention'd, it hath this Conveniency, that it excludes the Air, better than if the Receiver had a Stop-cock, in most *Experiments*, tho' in some it is less serviceable.

But most of the following *Experiments* may be try'd in our First *Engin*, if the following Alterations be made. And First, If a square Board, and a suitable Iron Plate, such as is made use of in this *Engin*, be fasten'd opposite to the Iron Rack, to the Upper Part of the great Cylinder, and a Glass Tube, like that just now describ'd, be fix'd to the Lower Branch of the Stop-cock, with a Cement, made with near an equal Proportion of Wax and Turpentine, in Winter, and three Parts of Wax to two of Turpentine in Summer; for the Ingress of Air being thus prevented, upon drawing down the Sucker, the Air, by Virtue of it's own Spring, will force it self out of the Receiver.

CHAP.

C H A P. XXX.

A Continuation of New Experiments concerning the Spring and Weight of the Air and their Effects, by way of Letter to the Right Honourable the Lord Clifford and Dungarvan.

My Dear Lord,

HAVING already given your Lordship an Account of the Design and Scope of our Mechanical Experiments, without any further Preface, being encourag'd by your Acceptance of my last, I shall proceed to a Continuation.

E X P E R I M E N T I.

Concerning the Raising of Mercury a great Height in an open Tube, by the Spring of a small Quantity of included Air.

IN order to make an Estimate of the Force of the Air's Spring, in it's several Degrees of Expansion; We fill'd the fourth part of a Viol with Quicksilver, the Neck of which was none of the largest, in which we fix'd a Glas Tube with hard Wax, the lower End reaching almost to the Bottom of the Quicksilver, and the upper almost a Yard above the Viol, which being convey'd into a Receiver (*See Plate 5. Fig. 1.*) which was pretty Tall, upon an Exsuction of the Air in the Receiver, that in the Viol expanding

*See Plate 5.
Fig. 1.*

panding it self, rais'd the *Mercury* 27 Inches in the Tube ; yet when the Air was again admitted into the Receiver, it subsided so far as to be almost; if not quite equal with the Surface of the *Mercury* in the Viol : And this Experiment was try'd before the Famous Savilian Geometer Dr. *Wallis*, tho' it does not constantly succeed alike, it sometimes rising higher than at others.

In which Experiment the following Observations were to be made. *First*, That so much Air being blown into the Viol, to try whether it was stanch, as was able to raise the *Mercury* three Inches in the Pipe, upon the Exsuction of the External Air in the Receiver, the *Mercury* rose 30 Inches above that in the Viol.

Secondly, When the *Mercury* is taken out of the Receiver, it does not suddenly subside as low as before it's Ascent, the Air being a little more Expanded by the Heat of the Cement when melted with an Iron.

Thirdly, Whilst the Air included in the Viol retains any considerable Springiness, after each Exsuction the *Mercury* will be rais'd by the Force of its Expansion, a considerable Height above what that Air is able to suspend it at, and makes several Vibrations before it settles.

Fourthly, Upon the first Exsuction the *Mercury* rises near $\frac{1}{3}$ of the whole Weight that the Expansion of the included Air is able to raise it, and continues every subsequent Exsuction to rise less and less as the weight of the suspended *Mercury* encreases, and the Spring of the Internal Air grows weaker, and as the *Mercury* rises less every Exsuction than it did before, so are the Vibrations less considerable.

Lastly,

Lastly, Having observ'd the Weight of the Air in a good Barometer, when it was but light, the *Mercury* was rais'd to 29 and $\frac{1}{2}$ tho' soon after the Tryal it was but 29 Inches high.

To make an Estimate of the Quantity of Air which rais'd the *Mercury* to the usual height, we counterpois'd the Viol, and then filling it full of Water, we found it to weigh about 5 Ounces 2 Drachms, and about 20 Grains; but so much being pour'd off, that the remaining Water only fill'd the Space which the *Mercury* was before contain'd in, it weigh'd 1 Ounce 2 Drachms 14 Grains, so that the Air which by it's Expansion elevated the *Mercury*, fill'd the Space of no more than 4 Ounces and a few Grains: The Diameter of the Pipe employ'd in this Experiment was no more than the $\frac{1}{4}$ of an Inch.

An Argument
against a
Fuga vacui.

But besides the Spring of the Air, from this Experiment we may learn, what is to be thought of what some Learned Men teach concerning the Suspension of Quicksilver by a *Funiculus*, and, it's rising to avoid a *Vacuum*; for were the first true, it might be demanded, why that *Funiculus* raises it not above 27 Inches; and as for the latter it's objected, that the *Mercury* being unable adequately to fill up more Space by rising, than if it rose not, the Reason must be invalid.

E X.

E X P E R I M E N T II.

A good Quantity of Air raised the Mercury in an open Tube, no higher than the Weight of the Atmosphere does in a Baroscope.

HAVING put a sufficient Quantity of *Mercury* into a large Bottle, capable of containing about 55ij, we immers'd the one End of a long slender Tube, below the Surface of the *Mercury*; and having clos'd the Neck of the Viol with Cement, it was convey'd into a Receiver different from the former in nothing but Size; where we observ'd, that the Quantity of Air being greater in this Viol, than that made use of in the former Experiment, it was capable of expanding further, and of raising the *Mercury* to about 29 Inches and about $\frac{1}{4}$ out of which half an Inch being deducted, for the height it was elevated to by Air injected to try the Stanchness of the Bottle, the Spring of the Air included in the Bottle, rais'd it to 29 Inches and about $\frac{1}{4}$; The Weight of the Air in a *Baroscope* at the same time, elevating the *Mercury* 29 Inches and $\frac{1}{4}$, which was $\frac{1}{4}$ higher than the elevated *Mercury* in the Receiver. But having continu'd to ply the Pump still longer, we learn'd, that the Spring of the included Air was incapable of raising it higher, than the Weight of the *Atmosphere* did in the *Baroscope*.

This Experiment was several times repeated with the like Success, but once, the Pump being ply'd more than usually, the Air contain'd in a Green Glass expanded so violently, that tho' it could

could not raise the *Mercury* higher, it broke the Glass with such violence, that the Piece which flew off crack'd the Receiver.

EXPERIMENT III.

The Spring of the included Air, will elevate Mercury almost to an equal Height in Tubes of a different Bore.

IN order to try, whether the same Quantity of Air would by it's Expansion raise the *Mercury* to the same Height in a narrow, as in a Cylinder of a larger Diameter, we repeated the former Tryal with a Pipe of the same Diameter, but much longer; in which the Spring of the Air rais'd the *Mercury* to 28 Inches and $\frac{1}{4}$, the *Mercury* in the *Borometer*, being 29 Inches and $\frac{1}{4}$ high at the same time. So that the Air was able by its Spring, to raise the Quicksilver within an Inch as high in a large Tube, as in a smaller: And when the Spring of that Air was no further able to expand it self, the Parts of it being put into Motion by Heat, the Spring of it was so much increas'd, as to raise the *Mercury* $\frac{1}{4}$ of an Inch higher.

EXPERIMENT IV.

A new Hydraulico-Pneumatical Fountain made by the Spring of uncompress'd Air.

HAVING put a Quantity of Water into a Bottle, and immers'd the End of a Glass Tube a little below the Surface of it, which was about

about 3 Foot long, the Interstices betwixt the Neck of the Bottle and the Pipe were fill'd with Cement (*see Plate 6. Fig. 2.*) and the whole See Plat. 6 Fig. 2. was convey'd into a Receiver. And because the Pipe was too long to be contain'd in the Receiver, another made of White Glass was Cemented upon the former, to the middle of whose Cavity, the upper End of the Pipe extended, so that the Motions of the rising Water had more Space to move in, when the Pump was set on work; where it was observable, that upon the first Exsuction the Pressure of the external Air being taken off, that contain'd in the Bottle, expanded it self so powerfully, as to raise the Water in the Tube with such Force, that it flew violently against the Top of the Receiver; but as the Air in the Bottle was lessurely expanded, and came nearer to an *Equilibrium* with that in the Receiver, the Spring of that in the Bottle, being less powerful, the Water in the Tube gradually ceas'd in its Ascent, unless the Pressure of the external Air was taken off by a fresh Exsuction.

In which Experiment, the following Particulars were to be noted; First, that as the upper Orifice of the Tube was narrower, the Water would rise slower, and the Experiment would be longer continu'd. Secondly, If a Pipe be Cemented upon the Top of the Tube, and branch'd out into several small ones, with Pinholes in the Ends of them, the Water will fly out, as out of Artificial Fountains in *Grotto's*. Thirdly, If the Bottle to whose Neck the Tube was Cemented, was larger, the Water would rise so much the longer; and the Experiment might

be reiterated by first letting in the Air again, and then exhausting the Receiver by pumping it out afresh.

From the *Phænomena* exhibited by this Experiment, it appears, that the Spring of the Air was able to raise the Water in the Tube to a much greater Height than the Pipe we made use of. Secondly, From hence it appears, that Water contain'd betwixt two Parcels of Air, may be put into Motion by its Spring, without the Concurrence of adventitious Heat. Thirdly, we observ'd, That when the Air was in a great Measure exhausted, the upper Receiver being taken off, the external Air press'd the Water quite down to the Bottom of the Tube, and several Bubbles getting through the Water, joyned themselves with the Air in the Bottle: But what was more strange was, that when the Receiver had been taken off a considerable time, several Bubbles of Air continu'd to make their way through the Water, as if the Spring of the Included Air, being before expanded, could not be brought again to its former State of Compression; but like a Balance put in Motion, continu'd several successive Vibrations, resisting each Impress of the *Atmosphere*.

But the Chief Remark in this Experiment was, that the Salient Water in the Receiver, form'd several large Lines, some of which were Parabolical, when the Receiver was pretty well exhausted.

EXPERIMENT V.

About the Production of Heat by Attrition in the exhausted Receiver.

IT being the Opinion of some Learn'd Men, that the Incalcescence of solid Bodies depends on the Attrition, or violent Agitation of the intercepted Air; To try how far this might be true, I caus'd a strong Spring of Iron or Steel (See Plate the Sixth, Fig. 3.) Figur'd much like the Lathe of a Cross-bow, to be fix'd to a staple Trencher: On the upper Part of the Spring was fix'd a Concave Piece of Brass, like a Burning-Glass, about 2 Inches Diameter, and moderately slender; to the Concave Superficies of which, was fix'd a Convex Piece of the same Metal; which had a square Handle on the upper Part, to which was fix'd a square piece of Wood, the other End being fix'd to the Basis of a Wooden Pillar, made use instead of our Vertical Cylinder; and the upper End of this Pillar was fix'd to the Turn-Key, being of such a Size, that when the Stopple was depress'd into the Socket made in the Brass Cover, the Concave and Convex Superficies of the two Pieces of Brass, contain'd betwixt the Wooden Pillar and the Spring, were squeez'd together, and the Spring in some measure expanded.

See Plate 6.
Fig. 3.

All things being thus provided, and a Mercurial Gauge convey'd into the Receiver, a Wimple was fix'd to the Top of the Stopple, which being turn'd round for some time, and the Air being exhausted out of the Receiver, we

presently took off the Cover; and perceiv'd, that the contiguous Superficies of the Pieces of Brass, betwixt which we had laid some powder'd Amel to make them move more easily one upon another, were sensibly warm.

And the Experiment being repeated a second time, and the Air so far exhausted, that the Mercury was no further depress'd, they grew so hot, that I could scarce endure to touch them; and a considerable Degree of Warmth succeeded, when the Experiment was try'd with two Pieces of Wood, the one of Oak and the other of Beech.

From which Experiment it appears, that Attrition of Solids may cause a considerable Warmth, when the Air betwixt their Superficies is exhausted.

EXPERIMENT VI.

About the disjoyning of two Marbles (not otherwise to be separated without a considerable Weight) upon a Removal of the Pressure of the Air in the Receiver.

HAVING several times suspended two flat Polish'd Marbles, whose contiguous Superficies were moistned with Oyl, to keep the Air from getting in betwixt them, upon a considerable Exsuction of the Air, they would sometimes fall asunder in the Receiver, at the eighteenth Suction, and sometimes at the eighth; tho' a Pound Weight was only suspended at the lower; yet in the open Air, where they were

com-

compress'd by the ambient *Atmosphere*, they were able to sustain 80 Pound without separating.

But having provided a Receiver with a Brass Cover (See Plate 6. Fig. 4.) and suspended two Contiguous Marbles in it, with a Weight of a few Ounces at the Bottom of the lowest, the String which suspended them being fix'd to the Bottom of the Brass Stopple in the middle of the Cover by turning the Stopple, and by that means shortning the String, the Marbles were rais'd up in the Receiver, but upon drawing out the Air, they presently fell asunder; yet having so contriv'd the Matter, that the lower should not fall too far, the other was let down to it, and upon the Re-admission of the Air, they were so closely compress'd together again, that they could not be separated as easily as before: Yet if by turning the Stopple, the uppermost was rais'd before the Air was let in, it would leave the lowermost behind it.

See Plate 6.
Fig. 4.

EXPERIMENT VII.

A way to break Flat Glass speedily, by the Weight of the Atmosphere.

TO make it appear, that the round Figure of a Body enables it to resist a more violent Pressure from the *Atmosphere*, than Bodies otherwise shap'd; We made use of a Brass Hoop, about 3 Inches high, and 3 Inches and $\frac{1}{2}$ in Diameter, and Cementing a round Piece of Glass upon the one Orifice, the other was joyn'd to the Receiver with Cement; and upon drawing out

the Air, the *Atmosphere* press'd so strongly upon the Glass, as to burst it asunder with a considerable Noise, like that of a Pistol. How far this may contribute to account for the Noise which accompanies the Explosion of Gunpowder in Pistols, we leave others to consider.

EXPERIMENT VIII.

The breaking of the Glass Plates in the foregoing Experiment may be accounted for without a Fuga Vacui.

THAT the breaking of the Glass Plates did not depend on Nature's Abhorrency of a *Vacuum*, appears hence; for if instead of the former Brass Hoop, we make use of a Vessel Figur'd like a *Conus Truncatus*, or a Sugar-Loaf, the Cone being cut off; if the lower Orifice be large, and the upper not above an Inch Diameter, the Glass Plate Cemented to the larger Orifice, will break when the Receiver is exhausted; but if the smaller Orifice be upwards, the Glass Cemented to it will be whole; whereas did Nature's Abhorrency of a *Vacuum* cause the former, it would have the same Effect in the latter: Wherefore I rather think the Reason why the latter did not break as the former, was because a small *Basin* of the *Atmosphere* presses upon it, which it is abler to resist than a larger Plate of Glass.

EX-

EXPERIMENT IX.

NOT to mention, of what Advantage it might be, to have a Good Method to break Bladders fill'd with Air, in our exhausted Receiver, by supplying it with Air speedily, and without danger of letting in too much from without; I shall intimate, That if a blown Bladder be contain'd in an exhausted Receiver, the Internal Air will be so powerfully expanded, as to distend the Bladder, and stretch it's Fibers, which when taken out again, and the Bladder at the Neck, being ty'd something nearer than before, the Bladder so distended with Air, and not liable to give way a second time to the Spring of the Included Air, the next time it is put into the Receiver, it is apt to burst.

*A Bladder
burst by the
Spring of
the Included
Air.*

EXPERIMENT X.

*A Considerable Weight rais'd by the Spring of the Air
included in a Bladder.*

TO shew that the Force of the Air's Expansion is so great, that $\frac{1}{4}$ of a Bladder, being fill'd with it, is able to distend it so powerfully, as to swell it up, tho' a considerable Weight be ty'd to the Bottom of it, to keep it from Rising; we fill'd the fourth Part of a Bladder with Air, and tying the Upper Part of it to the Stopple, it was suspended in our Receiver, with a Weight suspended by a String, which was ty'd to the Bottom of it; where we observ'd, That upon the Exsuction of the Air, the Included Air ex-

panded it self, and distending the Bladder shortned it so, as to raise 15 pound weight.

And another Bladder, having both Ends ty'd to the Stopple, and a Weight suspended at the Middle, of no less than 28 pounds, the expanding Air rais'd that an Inch from the Bottom of the Receiver; but when the Air was again admitted into the Receiver, it fell down again.

EXPERIMENT XI.

*Bubble
Hermeti-
cally seal'd,
broke by the
Air inclu-
ded.*

HAVING clos'd a Glass Bubble Hermetically seal'd, in our Receiver, and pump'd out the Air more than usually in such Experiments, about four Minutes after the Pump ceas'd to work, the Bubble unexpectedly flew into so many pieces, and with such force, as to be broke against the sides of the Receiver, into a Powder as small as Sand: But this sort of Glass being capable of stretching a little before it breaks, may be a Reason why the Experiment does not always succeed, the Spring of the Air contain'd in it being weaken'd by that Expansion of the Bubble.

EXPERIMENT XII.

Tryals representing the Force of the Spring of Uncompress'd Air upon Staple Bodies.

THE I. TRYAL.

HAVING cemented a Glass Plate upon the Brass Hoop, mention'd in the Seventh Experiment, and joyn'd the other Orifice of the Hoop with

with Cement to the Pump, upon that, a Large Receiver was fix'd: So that the Hoop supply'd the place of a Receiver, and the Receiver kept the *Atmosphere* from pressing upon it; yet, upon an Exsuction of the Air out of the Hoop, the Spring of that contain'd in the Receiver, broke the Glass Plate into an hundred pieces.

The II. TRYAL.

AND a Receiver shap'd like a Tumbler, which was capable of containing only a sixth part of what the Large Receiver did, being made use of, the Spring of so small a Quantity of Air, presently shatter'd the Glass Plate in pieces.

The III. TRYAL.

BUT a Large square Glass capable of hold-^{The Force of the Air's Spring.} ing a Pound, being made use of instead of the Hoop and the Glass Plate, upon the Exsuction of the Air, it was broke in pieces, both when the Large Receiver was whelm'd over it; and likewise, when a Receiver not much higher than it self was made use of.

In which *Experiments* we observ'd, That the Air making a greater Pressure on the Sides of the Bottles, than the Top, first broke them. And it was further observ'd, in the last *Experiments*, that the Glasses did not fly in pieces, till some time after the last Exsuction.

But lest it should be question'd, Whether the Glasses were broke by the Pressure of the Air in the Receiver, we repeated one of the former
Tryals,

Tryals, with the Brass Hoop, leaving a communication betwixt the Receiver, and the Cavity of the Hoop, a small Tube, whose Cavity was no wider than the Diameter of a Hair, being lodg'd in Part of the Cement; and upon plying the Pump, we found, that the Air, having a free tho' a small Vent out of the Receiver, did not break the Plate as before.

Yet notwithstanding, if the Air be suck'd out of the Hoop too fast, that in the Receiver, not finding quick Vent, will break the Glass Plate, the Pressure of the Air in the Receiver, being too strong to be ballanc'd, by the Resistance of the Air in the Hoop: And for a like Reason a slender Pipe, blown at the Flame of a Candle, upon it's first Removal into the Cold, hath it's sides, if thin, squeez'd nearer together, the Pressure of the Outward Air being greater than the Resistance of the Internal.

EXPERIMENT XIII.

Suction is able to raise Mercury no higher in Pipes than the Weight of the Atmosphere impels it.

See Plate
the 5. Fig.
the 2.

HAVING fitted one End (see Plate 5. Fig. 2.) of a Brass bent Pipe to a Stop-cock, and the other End to the Top of a Cylindrical Glass Pipe, near 50 Inches long, the lower End of it was immers'd in a Glass of stagnant Mercury: And tho' the Pump was set on work, yet was it not able to raise the Mercury above thirty Inches, by frequent and reiterated Suctions. But Water being substituted instead of Mercury, it rose, at the first Exuction, to the Top of the Pipe;

Pipe; and when the Stop-cock was open'd, it would run down through the Exhausting Brass Syphon. From whence it appears, that the Rise of *Mercury* depends not on Suction, or a *Fuga vacui*, whatever some Learned Men teach; but is rais'd by the weight of the *Atmosphere*; since a *Baroscope* consulted at the same time, made it appear, that the *Atmosphere* was able to suspend it at such a Height.

And as this is an Argument against those that dispute for a *Fuga Vacui*; so it is against those that hold, that it depends upon the Attraction of a Rarify'd Substance in the Top of the Pipe; for tho' we could rarify the Air further, by continuing the Action of the Pump; yet the *Mercury* would not rise one jot higher.

A N N O T A T I O N.

BUT the Syphon, here mention'd, being elsewhere made use of, it may be requisite to Observe: First, The Pipe which bends so much, is made of Metal, to make it less subject to break: Secondly, The End of it, which is joyn'd to the Stop-cock, must be a little wider than any other Part, to admit the Shank of the Stop-cock: Thirdly, The Cement which joyns the Brass Pipe and the Stop-cock, being apt to be loose; I rather make choice of one, to which a Stop-cock is fix'd, together with a Glass Syphon, about 10 Inches high, (see Plate 5. Fig. 2. where the whole is represented). And tho' this Additional Glass makes the Experiment longer, and more tedious, yet it is more useful and secure.

E X P E-

E X P E R I M E N T XIV.

The different Heights to which the Liquors may be elevated by Suction, accordingly as their Specifick Gravity varies.

See Plate
the Fifth,
Fig. the
Third.

FROM Experiments already laid down, it appearing to what Height *Mercury* may be rais'd in a Tube; we may guess at what Height *Water* might be suspended, by considering that it is 14 times lighter than the former. But to be further satisfy'd, I caus'd a small Pipe, which branched it self into two (see Plate the 5th Fig. the 3^d) So that a Cylinder being fix'd to each Branch, the Liquors contain'd in the Vessels, in which the lower End of the Pipe was immers'd, would rise proportionably as their Specifick Gravity enabl'd them to resist the Pressure of the *Atmosphere*; which being done, and the Pump set on work, *Water* rose in one of the Cylinders to 42 Inches, and the *Mercury* in the other Tube not above 3 Inches; so that the *Water* was fourteen times higher than the *Mercury*. And to make the Experiment more satisfactory, we let Air into the Receiver, till the *Water* subsided to fourteen Inches, and at the same time the *Mercury* was sunk to about an Inch; for in this Experiment it was observ'd, That the Proportion was not so exact as 1 to 14 precisely Specifies, but thereabouts.

From this Experiment, we may draw Arguments, not only against what is taught concerning *Nature's* Abhorrency of a *Vacuum*; but it may likewise more nicely inform us of the
Speci-

Specifick Gravity of Liquors: For having put into one of the Vessels, under the Glas Tubes, Fresh Water, and into the other Salt Water; when the Fresh Water rose to 42 Inches, the Salt Water was but 40 Inches high. But having made use of a Brine, made of Sea-salt, melted in the Air, instead of Salt Water, when the Fresh Water was rais'd to 42 Inches, the Brine did not exceed seven. I likewise put into one of the Vessels, when this *Experiment* was over, a Solution of Pot-ashes, and Common Water into the other, and when the Water rose to 42 Inches, the Solution was rais'd but to 30.

E X P E R I M E N T XV.

To what Heights Water and Mercury may be rais'd proportionably to their Specifick Gravities.

HAVING put *Mercury* into a Bottle, and pour'd Water into the Bottle upon the *Mercury*, we immers'd one Pipe so low, as to have it's End in the *Mercury*; and another Pipe was likewise immers'd in the Water only; which being fix'd by the help of a Cement in the Neck of the Bottle, the whole was convey'd into the *Engin*, and the Pipes being each divided into Inches, by hard Wax, with which they were mark'd, we observ'd, that the Water rose 15 times as high as the *Quick-silver*.

E X P E-

EXPERIMENT XVI.

The Former
Experi-
ment Illu-
strated.

HAVING put *Mercury* into a short Tube, and Water into one that was longer; both of them being Hermetically seal'd at one End, we inverted them both, the End of each resting in a Distinct Vessel; which being convey'd into the Receiver, the Water in the Cylinder did not in the least subside, till by Pumping out the Air, the *Mercury* subsided within 3 Inches of the Bottom, which was sooner than it ought, according to Statical Rules, which we conceiv'd to proceed from some Aiery Parts, lodg'd in the Pores of the Water, which rising to the Top of the Cylinder depress'd it by their Spring; yet the Water, when the *Mercury* subsided to the Height of an Inch, was near as high as before.

EXPERIMENT XVII.

The greatest
Height to
which Wa-
ter may be
rais'd by
Suction, &c.

See Plate the
Seventh,
Fig. 1.

TO try how high Water might be rais'd by Suction in a Pump, I provided a long Tube, about thirty Foot long, being made of several Tin Pipes, closely joyn'd together with Soder, and cover'd over with a Black Cement; which, to keep it from sticking to our Hands, we cover'd with Plaster of *Paris*: To the upper End of this Pipe, was fix'd a Glass Tube, about three Foot long; and to the Top of that was fix'd another Pipe, consisting of two pieces, which made a right Angle with each other, part of which was Parallel to the Horizon, and the other Perpendicular; the lower End being fix'd to the *Engin*, which was plac'd upon a Flat-roofed House: And

a Vessel fill'd with Water, being put under the End of the Pipe below, the Pump was set on work; and the Water, after a few Exfuctions, was rais'd to the middle of the Glas Tube, emitting several Bubbles, which proceeded from the Air, formerly lodg'd in the Pores of the Water.

But the chief Aim of our *Experiment*, being only to try to what Height the Water could be rais'd, I caus'd the Pump to be nimbly ply'd, till the Water could rise no higher; which being done, and the Height of the Water measur'd by a String, we found it to be 33 Foot, and about six Inches; *Quick-silver* in a *Baroscope*, at the same time, standing at 29 Inches, and about 3 eights of an Inch; so that the Water was near fourteen times as high as the *Mercury*.

In which *Experiment*, that the upper part of the Tube was sufficiently exhausted, appear'd from several Circumstances; as First, If any Air got in at Crannies in the Pipe, it would rise in Bubbles, easily to be distinguish'd, from those which rose from the Pores of the Water; and tho' the Quantity of those Bubbles was considerable, yet more Air being thrown out by the Pump, than could get in, it must needs be empty enough. But,

In this *Experiment*, it was to be noted, That when first the Water appear'd in the Glas Tube, they would be very numerous, and form a Froth; yet, when the Pumping was further continu'd, they grew less and less: Secondly, we observ'd, that the Water made several Vibrations in its Rise; which, tho' near a Foot at the first, grew less and less. Thirdly, it may be observ'd, that the *Baroscope*, consulted before, some time after,

was

was noted to have risen considerably; so that had the *Experiment* been repeated again, the Water would have been buoy'd up a good deal higher.

Now from this *Experiment* it appears, how improbable it is, what some Men teach concerning the Rise of Water, in Spiral Pipes, up to the Top of high Mountains; since it is evident, that it cannot be drawn higher than 36 Foot, by a Sucking Pump:

EXPERIMENT XVIII.

About the Bending of a Springy Body, in the Exhausted Receiver.

TO be satisfy'd how much the *Elasticity* of Bodies depends on the Influence of the Air, I fix'd one End of a Whale-bone in a Trencher, and ty'd a Weight to the other, by which it was bent, so low, as almost to touch the Plane under it. This being convey'd into our Receiver, upon the Exhausting of the Receiver, I could not perceive any Alteration.

EXPERIMENT XIX.

Concerning the making of Mercurial Gauges, whereby to estimate how much the Receiver is exhausted.

Several Gauges have been made use of to discover, when the Receiver is well exhausted, as by suspending a Bladder, which is almost empty of Air, or by inverting a small Tube,

Tube in which Spirit of Wine was contain'd; but the former taking up too much Room in the Receiver, and the latter not discovering whether the Receiver was exhausted, or not, till the Air contain'd was too much Raref'd, for any Considerable Observations; Therefore, to enable me to make more Observations in the several Degrees of the Receiver's Exsuction, I took a slender Pipe of Glass, about 10 Inches long, and as small as a Goose Quill, and having melted it at a flame, so as to soften it, and make it apt to be bent; I caus'd it to be put into the Form represented by (Plate 5. Fig. 4.) so that about an Inch of the lower Leg being fill'd with Air, and the rest of that, as well as the greatest Part of the short one, being fill'd with Quicksilver, the Expansion of that Air might easily be perceiv'd, by passing a Piece of Paper upon that Tube, divided into several exact Parts; for as the Receiver is more or less expanded, the Air in the longer Leg of the Gage, will be extended to some of those Marks; and if when the Air is so expanded, the Experimenter desires to know, at each of those Marks, how much the Receiver is exhausted, it will appear by letting in as much Water as the Capacity of the Receiver is able at that time to hold; so that if when the Air is at any determinate Mark, the Water be let in, and it appears, that the Air in the Receiver was so far Evacuated, by observing how much Water will be admitted, when the Air is expanded to each Mark; the Gage, for the future, will not only inform us, how much the Air is exhausted; but by the help of the small Gage, a larger may be made, by putting both into an

See Plate 5.
Fig. 4.

exhausted Receiver at once, for by observing, when the Air is expanded to each Mark in the little one, how far it is expanded in the large one; we may learn, how much the Receiver is exhausted, for the future, by taking notice of the Expansion of the Air in the Leg of that larger Gage. And,

This Gage is much more useful than some others: First, because the *Mercury* being a heavy Body, the Air, by expanding it self, is less apt to make it run over, or to make it's way in the Form of Bubbles through the Mercurial Cylinder, as it would if other Fluids were made use of instead of it. Secondly, The longer Leg of the Gage is to be mark'd, by sticking Wax or Knobs of Glass to the Pipe, every Tenth being of a different Colour from the rest, at equal Distances from each other, which Divisions will be less subject to be rubb'd off than Papers, which are also subject, in some Experiments, to be wet. Thirdly, The Leg of the *Syphon* in which the Air is included, may be either seal'd up, before it is divided by the aforementioned Marks, or after, by drawing out the End of the Tube into a small *Apex*; and when about an Inch of the Pipe is fill'd with Air, it may be seal'd up by blowing a Lamp Horizontally upon the *Apex*. Fourthly, Where very Nice Observations are to be made, and the Receiver admits of a longer Gage, instead of *Mercury* we may make use of a Tincture of Roses, or of Spirit of Wine with *Cocheneil*; in which, the Exsuction of the Air will be more nicely represented. Fifthly, We may vary the Mercurial Gage, by ordering the shorter Leg, so that it may have a Bubble
about

about half an Inch Diameter, at an Inch distance from the *Basin* of that Leg, which Bubble must have a Pipe upon the upper Part of it to give way to the Air; which Bubble hath this Advantage above the other, that less Air may be contain'd in the Top of the longer Leg; since the *Mercury* not being capable of being rais'd so high, the Rarefaction of the included Air will be render'd more apt to be estimated by the Eye. Sixthly, This Gage is much more useful than those mention'd by other Authors, because it gives us an Account of the several Degrees of the Air's Rarefaction.

EXPERIMENT XX.

An easie way to make the Pressure of the Air sensible to the Touch.

THE Pressure of the Air will be made sensible to the Touch, if a Tapering Tube of Brass, whose Cavity at one end is an Inch, and the other two Inches and an half wide, be fix'd to the Pump instead of a Receiver; for if when the larger Orifice is Cemented on the Pump, one presses the Palm of ones Hand upon the smaller Orifice, and the Pump be set on Work, it will be a difficult Matter to take off ones Hand, and not a little painful; but the Pressure of the Incumbent Atmosphere will have a much more sensible Effect, if the larger Orifice be upwards instead of the smaller.

The Pressure of the Air sensible to the Touch.

E X P E R I M E N T XXI,

About the subsiding of Mercury in the Tube of the Torrecellian Experiment, to the Level with the Superficies of the Stagnant Mercury.

THE lower Part of the Ball of a Bolt-head being circularly cut off, we made use of it for a Receiver, including a *Baroscope* in it, and upon the first Exsuction, the *Mercury* subsided from 29 Inches to 9 or 10, and by three Exsuctions more, would be brought to a Level with the Stagnant *Mercury*, but would rise to it's first Station again, as the Air was admitted in slower or faster.

In which Experiment it is to be noted ; First, that upon the first Exsuction, the *Mercury* was brought within an Inch of the Bottom, and continu'd several successive Vibrations before it settled at 10 Inches high. Secondly. If instead of drawing any out, Air be forced into the Receiver, it will raise the *Mercury* higher than it's former Station : Thirdly, The Receiver was so far exhausted, as to make the *Mercury* subside to a Level.

EXPERIMENT XXII.

*In Tubes open at both Ends, when Nature's Abhor-
rence of a Vacuum cannot be pretended, the
Weight of Water will impell Quicksilver no higher
in slender than in larger Pipes.*

TO prove that the Weight of the Atmosphere, may buoy up Mercury equally in large
as in smaller Tubes, I shall add the following
Tryals.

*The suspen-
sion of
Quicksilver
equal in
small and
wide Pipes.*

The I. TRYAL.

Having put as much Mercury into a Glass Tube, about two Foot and a half long, as reach'd 3 or 4 Fingers, the one End being seal'd Hermetically; we hung two Tubes by Strings to the Top of the former, so that the lower Ends of them were immers'd in the Mercury; which being done, we pour'd Water upon the Mercury, and observ'd the Mercury to be equally rais'd in the great Pipe, as in the little one, and the Water being suck'd out, it proportionably subsided in each.

The II. TRIAL.

Having pour'd a Convenient Quantity of Quicksilver into a Tube of Glass, near a Foot long, and filled two Pipes of Mercury of an unequal Bore, the one End of each being Hermetically seal'd, we immers'd them in the large Tube, contriving to open the lower Orifice, when be-

Ff 3

low

low the Stagnant *Mercury*; and I observ'd, that they not only both of them subsided to an equal Station; but Water being pour'd upon the Stagnant *Mercury*, the Weight of it buoy'd them up both alike in the Tube, and the Water being successively suck'd out, and put in again, the the *Mercury* in the Tube, proportionably fell and rose equally in both; no difference proceeding from the Wideness of their Diameters, in the Height of the *Mercurial* Cylinders.

EXPERIMENT XXIII.

At what Height Mercury Amalgamated with Tin, as well as pure Mercury, will be suspended.

HAVING fill'd a Glass Tube with *Mercury* Amalgamated with Tin, and inverted it, it did not fall below 31 Inches. In trying this Experiment, the following Particulars are to be noted: First, That if the *Amalgama* be too thick, it will be apt to stick to the Tube, and will likewise hinder several Aerial Corpuscles from flying away. Secondly, From hence it may be observ'd, that as the *Equilibrium* of *Mercury*, and the *Atmosphere* varies; so does it's Ascent in such Tubes. Thirdly, It would not be amiss here to consider, whether these two Metals penetrate each others Dimensions, as I have observ'd Copper and Tin to do; and by forming a new Metalline Substance to render the Composition heavier than the Weight of the two single Ingredients.

EXPERIMENT XXIV.

A Method of making Barometers, which may be carried to distant Countries.

TO make a Portable *Barometer*, we took a Cylinder about 4 or 5 Foot long, and having bent one End at the Flame of a Lamp, so as to make the shorter Leg about a fourth Part as long as the other, sealing up the End of the longer Leg, we injected *Mercury* into the shorter Leg by a Tunnel, till it was rais'd about 3 Inches in both Legs; which being done, and the Orifice of the shorter Leg being stopp'd with the Finger, we inclin'd the longer Leg, and so by successively filling the short Leg, and inclining it so as to make it run into the longer, we fill'd the longer Leg quite full of *Mercury*, and by inclining it several times afterward, and permitting the Bubble of Air, which usually lies at the Top of the seal'd Head, to run through the Mercurial Cylinder backwards and forwards, we freed it from those Bubbles, which are usually in it's Pores. But besides this way of filling the Pipe, we have, with less Trouble, done it by making use of a Tunnel; which, when the Pipe is a little inclin'd, reaching a little above the Flexure of the Siphon, will fill the Tube without much trouble: And the Pipe thus fill'd with *Mercury* may, by often erecting of it, and shaking the Pipe so erected, be freed from those Aery Particles which commonly lodge in the Pores of the *Mercury*.

See the
whole Baro-
meter, Plat.
7. Fig. 2.

The *Barometer* being thus order'd, we contriv'd a Frame to carry it in, which was made of a Piece of Wood, in which a Gutter was cut for the Pipe to lie in; the lower End of the Frame being likewise so contriv'd, as to contain the short Leg of this Tube: The Pipe being lodg'd in this Gutter, we fix'd a Cover to one side of the Frame, with little Hinges; the other, when occasion requir'd, being fastned with Hasps.

And because the Motion the *Mercury* would be put into, would be apt to break the Pipe, were there too much Liberty given it to move in, or were there any Interstices betwixt the Pipe, and the Gutter it is lodg'd in; we took Care to lay Cotton both betwixt the Pipe and the Concave of the Frame, and betwixt the Cover and it; and that the empty Space which is usually above the Surface of the *Mercury* in *Barometers*, might not be prejudicial, we took Care to invert the Tube, and to fill the remaining Space unpossess'd with *Mercury* either with an Addition of *Mercury* or with Water, sealing up the Orifice of the shorter Tube Hermetically, till it came to be us'd again; and then, the Superfluous *Mercury*, may be taken away by immersing a small Pipe in it; which, if the upper Orifice be stopp'd with ones Finger, will take away so much as the Cavity of the immers'd Tube had receiv'd into it: But if Water be made use of, instead of *Mercury*, it may be lick'd up with a Sponge. And if by shaking of this *Barometer* in long Journeys any Particles should get out of the short Leg into the larger, by successively inverting the Tube, and permitting the Bubble of

of Air to pass backwards and forwards, the *Mercury* in the long Tube may easily be freed from Bubbles.

Of what Use this *Barometer* may be, in discovering the Weight of the *Atmosphere* in long Journeys, both at Sea and at Land, I shall leave to others to consider; only I shall annex this Advertisement, that sometime after I made this *Barometer*, having carri'd it about 33 Miles I observ'd, that it did not rise by $\frac{1}{4}$ of an Inch as high as it did before; but whether it might be imputed to the narrowness of the Pipe, or any other Accident, I cannot yet determine.

EXPERIMENT XXV.

What Height the Mercury in Barometers will be suspended at, at the Top of Hills. Some Observations of the Height of Mountains, especially, the Pic of Teneriff.

HAVING observ'd the Height at which *Mercury* was suspended at the Bottom of a Hill, and compar'd it with a *Barometer* made the ordinary ways; it was observ'd, that the Height it was suspended at, at the Top of the Hill, was $\frac{1}{4}$ part of an Inch below the Mark it reach'd at the Latter; and as the *Barometer* was brought lower, the *Mercury* in the Pipe rose higher and higher: But if such Observations could be made at the Top and Bottom of the Mountain *Teneriff*, the Experiment would afford further Proof of our *Hypothesis* concerning the Air's Spring and Weight.

An

An Appendix about the Height of Mountains.

The Height
of Moun-
tains.

Notwithstanding some Ingenious Men have taught, that the Height of the Atmosphere is of stupendious, and others confine it to narrower Dimensions; yet, I shall add some Observations, which may confirm what we have taught concerning it; and tho', as *Ricciolus* takes notice, the Jesuit *Rector Melensius* says, that of all the Clouds, whose Height he measur'd, they did not exceed 5000 Paces, yet if we allow Meteors and Comets to arise from Terrene Exhalations, and that the Height of Clouds varies according to the different Degrees of the Air's Rarefaction, it will follow, that the Height of most of them exceeds what *Carden* and *Kepler* allow.

But to proceed to what I have to relate concerning the Height of Mountains; I shall relate, what I have learn'd by Information. And first, the Ingenious Mr. *Sydenham* told me, that the Mountain *Teneriff* is so high, that the Top of it may be seen 60 Leagues off, and that he himself had discover'd it at 40 Leagues distance like a blew Pyramid above the Clouds; and he likewise told me, that the Island of *Madera* might be seen from it, tho' 70 Leagues distant; and that the *Great Canary* seem'd so near it, that one would think it possible to leap down upon it: And indeed, *Ricciolus* observes, that it might be seen 4 Degrees distance; and *Snellius* also allows the Height of it to be Ten Miles; tho' I believe, that the way he takes to calculate the Height of it, may be none of the truest; he likewise

likewise by Refraction, judging the Mountain *Caucasus* to be 51 *Bolonian* Miles high, which is not believ'd probable; since the Mountain *Teneriff* hath been observ'd, by one who took it's Height in a Ship at Sea, not to be above 7 Miles high in a Perpendicular Line, yet it is esteem'd the highest Mountain in the World; tho' If what *Aristotle* and others report of Mount *Caucasus*, be true, there may be others much higher than those. For tho', if measur'd from the Foot, or Level of that piece of Ground, which they stand on, they may be lower, yet considering that the Ground they stand on, may be much more protuberant, from the Level Superficies of the whole Globe, they may be much higher upon that Account,

EXPERIMENT XXVI.

The Pressure of the Atmosphere may be able to keep up the Mercury in the Torrecellian Experiment, tho' the Air presses upon it, at a very small Orifice.

IT being observ'd by several Learned Men, That *Mercury* is suspended at an equal height in a close Room, as in the open *Atmosphere*; to prove, that the Air having a Communication with the External, even at small Crannies, may have an equal Force, as if the *Mercurial* Cylinder was immediately subject to the whole *Atmosphere*; I shall add, That if the Tube, just before mention'd, for a Portable *Barometer*, be so drawn out at the Flame of a Lamp, that the Orifice is but about a tenth Part as big as before, the *Mercury* will be suspended at the usual Height; and the like will succeed, if instead of drawing the
End

End of the Pipe out so, a Cork be put into the End of the Tube, leaving but a small part of the Orifice open to the Outward Air.

EXPERIMENT XXVII.

An Oblique Pressure of the Atmosphere may be sufficient to keep up the Mercury at the usual Height, in the Torrecellain Experiment, and the Spring of a small quantity of Air may do the same.

See Plate the
7th. Fig. the
3d.

IF the the Shorter Leg of a Syphon, being bent, as represented by Fig. 3d. Plate the VIIth the Mercury be suspended at it's usual Height, it appears that the Pressure of the Atmosphere hath as strong Effects, if the End of the Tube, through which it is convey'd, only admits of the Pressure of the Air, which it receives downwards.

See Plate the
7th. Fig. the
4th.

But if instead of being so bent, the End of the Shorter Leg be Hermetically seal'd, as represented Fig. IV. Plate the VII. the Mercury is sustain'd at it's usual Height, it will appear, that the Spring of a small quantity of Air is able to bear up a Cylinder of Mercury.

N. B. If the Tube thus Hermetically seal'd, be shaken, the Mercury will form some Vibrations upon the Included Air; the Spring of it being compressed, and expanded again successively for a while.

But the former of these Tryals may be made in a Pipe, conveniently shapen before the Longer Leg is fill'd with Mercury, and the latter by stopping the Orifice with a Cork, and Close Cement, which may be pierc'd with a Wire, when this is us'd

us'd as a *Baroscope*; which way may be taken with a Travelling *Baroscope*.

EXPERIMENT XXVIII.

TO shew that the Suspension of *Mercury* in a Glas Tube, less than 30 Inches long, does not proceed from a *Fuga Vacui*, I caus'd one to be Hermetically seal'd at one End, the Length of it being about two Foot and a half; and fill'd it with *Mercury*, a small quantity of Water being left upon it; and when the *Atmosphere* was much lighter, I found that the *Mercury* subsided, and that there appear'd a small Bubble of Air in the Water, which being no bigger than a Pin's Head, was so far compress'd before, as not to appear.

EXPERIMENT XXIX.

The Ascension of Liquors in very slender Pipes, in an Exhausted Receiver.

HAVING tinged Spirit of Wine with *Cocheneel*, which bubbled in the Exhausted Receiver, for some time, several slender Pipes being put into it, it rose highest in those whose Bore was narrowest; but when the Air was let in again, the Liquor in both subsided to a Level: But two Pipes of different Bores, being let down into that Liquor a second time, tho' it answer'd the former Tryals in the Ascent; yet, the Surface in the slenderer Pipe, remain'd something above the other, when the Air was let in again. But what was more Remarkable, was, that tho' the Li-

Liquor in the Vessel, in this Tryal, emitted no Bubbles, yet that in the Ends of the Tubes did; which were suppos'd to be caus'd by the sides of the Glass, they were contain'd in.

EXPERIMENT XXX.

When the Pressure of the External Air is taken off, it is very easy to draw up the Sucker of a Syringe, tho' the Hole at which the Water should succeed, be stopp'd.

FOR a further Illustration of the Doctrin of the Spring and Weight of the Air, we made the following Tryals.

The I. TRYAL.

See Plate
the 8th Fig.
1st.

We took a Syringe of Brass (see Plate 8th Fig. 1st.) whose Barrel was about six Inches long, and it's Diameter about one Inch $\frac{1}{2}$, and having fitted the Sucker to the Barrel of the Syringe, we stopp'd the lower Orifice of the Syringe, and ty'd a good Weight to it; which being done, we let it down into the Receiver, tying a String to the Sucker, and another End of that String to the Turning-Key in the Cover of the Receiver; where we observ'd, That tho' when the Receiver was exhausted, we could, by turning the Key, draw up the Sucker easily; yet, when the Air was admitted into the Receiver again, it could not be lifted up with a less Force, than what was sufficient to overpower the Pressure of the Atmosphere, or the Air contain'd in Receiver; but the Air being once let in, when the Sucker was rais'd to the Top of the Barrel, the Pressure of it was so violent, as, by forcing the

the

the Sucker down into the Barrel of the Syringe, to break the String, which was ty'd to the Turning-Key.

The II. TRYAL.

Being a Variation of the former.

We took the former Syringe, and having ty'd a Weight, which weigh'd about two Pound and two Ounces, to the Sucker, we suspended it in our Receiver, the Orifice of the Barrel being first stopp'd with a Cork; and we observ'd, that after a few Exsuctions, the Weight drew down the Barrel of the Syringe; and when the Air was again let in, the Pressure of it rais'd it up much faster than it fell.

But in this *Experiment*, it is to be noted, that if Air gets into the Barrel of the Sucker, whilst it is drawn down, it will not be rais'd quite so high again as before. And likewise, the Reason why it is requisite, that so large a Weight should be ty'd to draw it down, is because it must not only overpower the Pressure of the Air, but also the Straitness which requires a Force to make the Sucker move in the Barrel.

Secondly, it is observ'd, that as the Weight did not overpower the Pressure of the Air, till a good deal was exhausted; so neither did it rise again, till a sufficient Quantity of Air was let in again.

EXPE-

E X P E R I M E N T XXXI.

About the opening of a Syringe, whose Pipe was stopp'd in the exhausted Receiver, and by the help of it, making the Pressure of the Air lift up a considerable Weight.

See Plate
8th. Fig. 2d.

HAVING clos'd up the Hole at the Bottom of the Syringe, with good Cement, we ty'd a hollow piece of Iron to the Barrel, into which several Weights being put, we ty'd the Rammer to the Turn-Key; and tho', when the Receiver was exhausted, we could draw up the Rammer without the Syringe; yet, upon a Reingress of Air, the Syringe and the Weights would be rais'd swiftly up: So that so small a Cylinder of Air as equalled the Barrel of the Pipe, was able to lift up the Weight of sixteen Pounds.

E X P E R I M E N T XXXII.

The Sticking of Cupping Glasses depends on the Pressure of the Air.

See Plate
8th. Fig. 3d.

TO make it evident, that the Sticking of Cupping Glasses, and the Pain which they cause, proceeds from the Pressure of the Air, we provided a Receiver, and a Large Glass, such as Plate the 8th. Fig. 3d. delineates; I caus'd the Cupping Glass to be apply'd to a Young Man's Hand; which being done, and his Hand apply'd to the Top of the Receiver, instead of a Cover, the Lower Orifice of the Receiver, having first been cemented on the Pump, upon

Chap. XXX. *the Spring of the Air, &c.*

upon the first Exsuction of the Air, the Cupping Glass fell off his Hand, for want of the Pressure of the External Air, to press against it.

EXPERIMENT XXXIII.

TO illustrate the former *Experiment*, we took a Brass Hoop, mention'd in the Fifth *Experiment*, and stretching a Bladder upon the upper Orifice of it, as upon the Head of a Drum, we ty'd it up in the Middle of the lower Orifice, and placing it upon a piece of Wood, which had a hole in the Middle for the Neck of the Bladder to hang through, we made several holes on the Lower Side of that Bladder; which being done, we suspended a Blind-head at the Turn-Key of our Receiver, and when the Receiver was exhausted, we let it down to the Bladder, and found, that when the Air was again admitted into the Receiver, the Pressure of it so press'd upon the Bladder, as to fix it fast to the Blind-head. See Plate the 8th. Fig.

But repeating the *Experiment*, and exhausting the Receiver more perfectly, we took out the Bladder thus fix'd to the Blind-head, and having ty'd the Glass to the Hook of a good *Statera*, and likewise a large Scale to the Neck of the Bladder, and put in Weights into it, till they amounted to 35 Pound weight; then the Weight, overpoising the Pressure of the External Air, the Bladder fell off: But in this *Experiment* it was observ'd, that as the Weights in the Scales grew heavier and heavier, the Bladder seem'd to be suck'd more and more into the Receiver. See Plate the 8th. Fig. the 5th.

EXPERIMENT XXXIV.

Bellows whose Nose is very well stopp'd, will open of their own accord, when the Pressure of the External Air is taken off.

AS an Argument of the great Force of the Air's Weight, it is observ'd, that when the Nose of a Pair of Bellows is stopp'd, it requires a Force able to overpower the Pressure of so large a Pillar of Air, as lies upon them, to open them; but when that Weight of the *Atmosphere* is taken off, the Spring of the Included Air is so strong, as to be able to raise and expand the Bellows of it's own accord.

*See Plate the
2th. Fig. the
6th.*

To make this Evident, we caus'd a Pair of Bellows to be made, whose Boards were circular, and near 6 Inches Diameter, without a Valve, the Nose of them being about an Inch long, and the Leather limber: Which Bellows, when full of Air, seem'd to be a Cylinder of about 18 Inches high.

The Nose of these Bellows being stopp'd, when they were empty'd of Air, we convey'd them into our Receiver, and observ'd, that when the Air was exhausted out of the Receiver, the Air contain'd in the Folds of the Bellows, and betwixt the two Bases lifted up the Higher a considerable Height.

E X P E R I M E N T XXXV.

An Attempt to examin the Motions and Sensibility of the Cartesian Materia Subtilis, or the Æther, with a Pair of Bellows, which were made of a Bladder, in the exhausted Receiver.

I N order to try, whether there be any finer Substance than Air, in the exhausted Receiver, we contriv'd to make a Pair of Bellows of a Bladder, whose Bases were Paste-board, the upper being cover'd with a Plate of Pewter, to which was fix'd a Leaden weight to press it down: Besides, over against the Nose of the Bellows, in which the Neck of the Bladder terminated, it was contriv'd, that the End of a Feather was fix'd so, that if any Subtle Matter were forc'd out of the Bellows, it should discover it self by moving that Feather.

*See Fig. the
7th. Plate
the 8th.*

The Bellows being thus provided, and the Pillars, to which the Feather is fastened, being joyn'd to the upper Basis of the Bellows, with Cement, we fix'd a Weight to the Lower Basis, and convey'd it into the Receiver; where we observ'd, upon the exhausting of the Receiver, that the Air in the Bellows rais'd up the upper Basis, together with it's Weight; and the Air rising out at the Vent, manifestly mov'd the Feather: But when the Receiver was quite exhausted, and the Weight upon the Upper Basis depress'd it violently, we could not perceive that the Feather was in the least mov'd, and the like was observ'd upon repeating the Experiment.

*See Fig. the
Eighth.*

E X P E R I M E N T XXXVI.

The great and seeming Spontaneous Ascent of Water, in a Pipe filled with a Compact Body, whose Particles are thought incapable of imbibing it.

WE took a slender Pipe, and having ty'd a Linen-cloth to the lower Orifice, we fill'd it with *Minium*; and immersing it in Water in a Wide-mouth'd Glass about an Inch, the Water ascended about 30 Inches; and the *Experiment* being again repeated in another, it rose 40 Inches.

In which kind of *Experiments*, the following Particulars were to be observ'd: First, That other Powders being made use of instead of this, the *Experiment* did not succeed so well; nor was the Success much better, when we made use of Ink instead of Water.

Secondly, Our *Experiment* succeeded the better, the finer and closer the *Minium* was: But if the Pipe be too small, the Event will not always be successful.

Thirdly, We observ'd, That the Water ascends not to it's utmost, under 30 Hours, and sometimes longer.

Fourthly, From hence it appears, That the Water in our Tube rose, without any swelling of the sides of the Tube, which some Learn'd Men ascribe the Cause of Water's Rising in Filtres to.

Fifthly, From hence it may be urg'd, as probable, That the Sap in Trees may rise after the like manner, being promoted by Heat, and a due Texture of Parts.

E X P E-

E X P E R I M E N T XXXVII.

Of the seeming spontaneous Ascent of Salts, along the sides of Glasses, with a Conjecture at the Cause of it.

I Have several times observ'd, that the watery Part of a Solution of *Sea-Salt* or *Vitriol*, being evaporated, the coagulated Salts would creep up the sides of wide-mouth'd Glasses, in which the Solution was contain'd; and not only so, but if the Experiment were longer continu'd, they would rise over the sides of the Glass, and cover the external Superficies with a Crust of Salt.

As for the Cause of so strange a *Phenomenon*, tho' I will not be positive in it; yet, it may not improbably depend on the like Cause, as the Ascent of Water in the Tube, mention'd in the foregoing Experiment.

For we may observe, that the Edges of Water are not only above the Superficies of the rest of the Water; but *Sea-Salt* as well as several others, chrySTALLIZE at the Top of the Liquor they swim in, and near the sides of the Glass, their Coagulation being promoted by the Coldness of it; which Salts, when once the sides of the Glass is beset with them, the Water may rise to the Top, for the same Reason that it does in the slender Pipe before mention'd, and Salts carri'd up to the Top of those, and coagulating there, still lay a further Bottom for their Ascent; and so successively, till they rise to the Top of the Viol: And that there are Passages betwixt these saline Parts, for the Water to ascend through, appears; since they may be broke off in Flakes,

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separate from each other: And if it should be thought, that the Water in such an Ascent, would dissolve the Salt; it may be answer'd, that the Water being so much Impregnated with Salt already, can imbibe no more; and consequently, for that Reason, when it runs down the outsides of the Vessels, coagulates by the way, being too thick and full of Salts to continue long fluid.

EXPERIMENT XXXVIII.

An Attempt to measure the Gravity of Cylinders of the Atmosphere, so that it may be known and express'd by common Weights.

The Weight of a Pillar of Air of a determinate size.

BEING desirous to know what was the Weight of an *Atmospherical* Cylinder of Air, of a determinate Diameter, I caus'd a Pipe to be made of Brass, whose Diameter was an Inch, and it's Length three; one End of which being clos'd up with a Plate of Brass, I counterpois'd it in a nice pair of Scales; and found, that it was able to contain about 137 Drachms 45 Grains of *Mercury*; which being multiply'd by Tens, a Cylinder of *Mercury* of 30 Inches, and consequently an *Atmospherical* Cylinder able to counterpoise it, must amount to 12 Ounces and about 6 Drachms. And by weighing Water in this Tube, before the *Mercury* was put into it, the Water weighing 10 Drachms 15 Grains, the Proportion of Water to *Mercury* seem'd as 13 $\frac{1}{4}$ to 1.

But in estimating the Weight of a *Cylindrical* Pillar of Air, it may be here requisite to advertise, that I made use of a Brass Cylinder, because the Cavities of a Glass Tube are unfit
for

for such an Experiment; since it is a hard thing to know, whether the Bore of such Tubes be equal throughout their Diameter.

The Weight of a Cylinder of *Mercury* being thus found, it will not be very difficult to know, the Weight of a Cylinder of a different Diameter, by the Assistance of the Doctrin of Proportions and the 14th Proposition of the 12th Book of *Euclid's* Elements. For since according to that, Cylinders of equal *Bases*, are to one another as to their Heights; and since, by the second Proposition of the same Element, such Circles as the *Bases* of Cylinders, are to one another as the Squares of their Diameters; and since Mercurial Cylinders will bear the same Proportion in Weights as they do in Bulk; The Rule will be, That as the Square of the Diameter of the Standard Cylinder, is to the Square of the Diameter of the Cylinder propos'd, so will the Bulk of the former be to that of the latter; and the Weight of that to the Weight of this; so that the Square of one Inch being 1, and the Square of 2 being four, the Weight of the latter will be four times the Weight of the former.

EXPERIMENT XXXIX.

The Attractive Virtue of a Load-Stone in the Exhausted Receiver.

TO try how far the Account given of the Attraction of a Load-Stone, depended on what some Modern Philosophers teach, viz. That the *Effluvia* of a Load-Stone pressing away the Air betwixt the Body attracted, that Air helps the Attraction, by pressing against the opposite

posite side of the Stone; We plac'd a vigorous Load-Stone in our Receiver, having adapted a Cap of Steel to it, to the lower side of which, a Scale with 6 Ounces of *Troy* Weight was fix'd, which being all the Load-Stone, besides the Steel and the Scale was able to keep up (all which being suspended at a Button, which was on purpose on the inside of the Cover of the Receiver) we observ'd, that tho' the Receiver was exhausted as much again as in common Experiments; yet, the Load-Stone sustain'd it's Weight almost as firmly as before the Pump was ply'd; and the Reason why it was not altogether, was, the thinness of the *Medium*; since the Weight suspended must be heavier, when the Air which was nearer proportion'd to their Weight was exhausted.

F I N I S.

A D V E R T I S E M E N T.

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